THE ENGINEER

AUGUST 28, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

MAKING LARGE TIMKEN BEARINGS

FOR 30 years British Timken have been making large Timken tapered-roller bearings.

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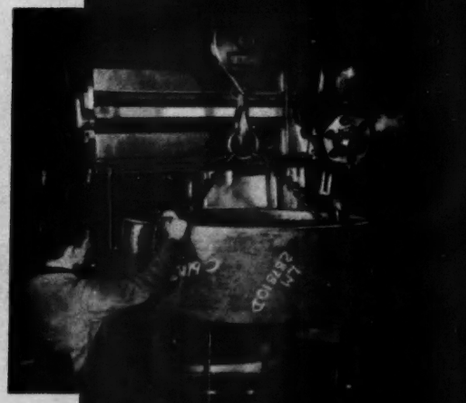
Some Timken bearings exceed 7 feet in diameter, others weigh as much as 4½ tons.

In this view of part of the Machine Shop, high-nickel-alloy steel forgings are being machined prior to heat treatment.



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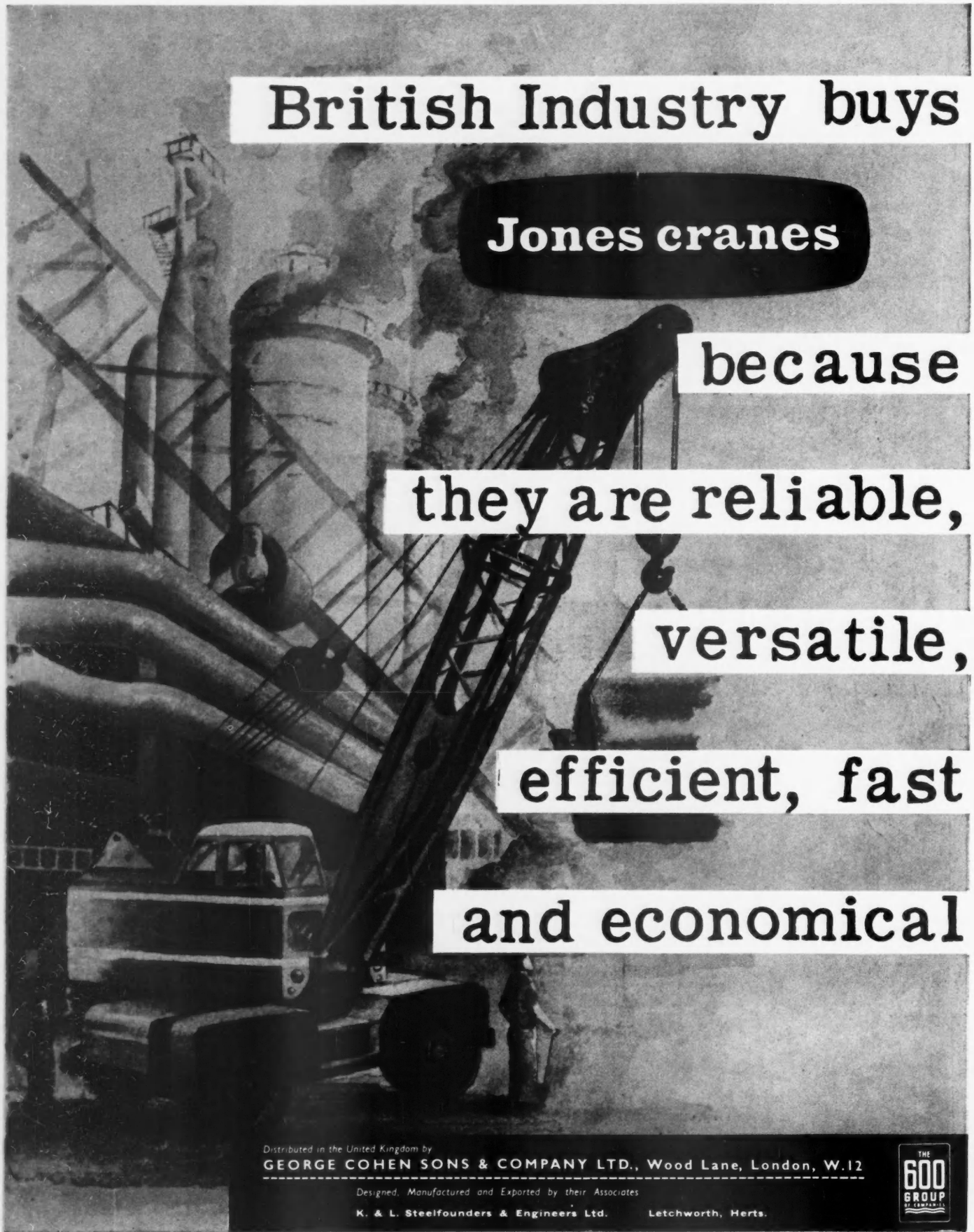
TAPERED ROLLER BEARINGS MADE IN ENGLAND BY

BRITISH TIMKEN LIMITED

DUSTON, NORTHAMPTON (HEAD OFFICE) AND DAVENTRY, NORTHANTS



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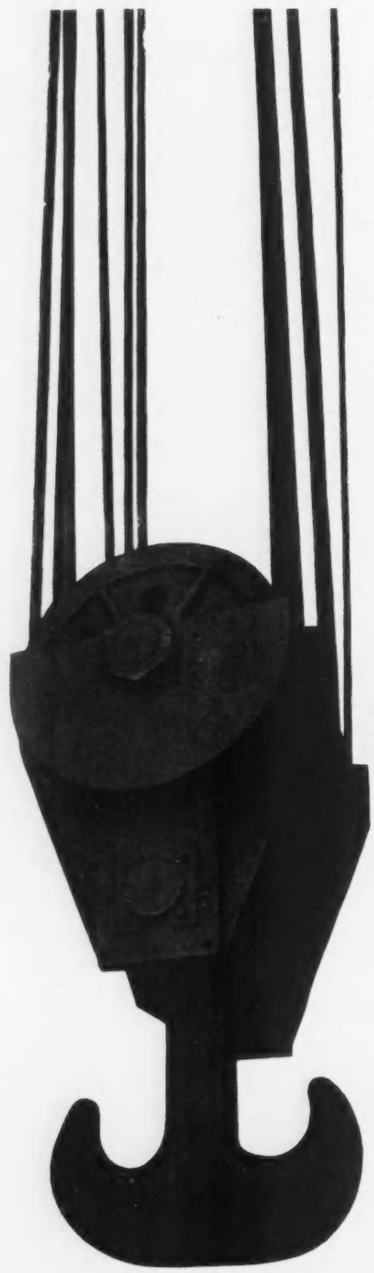

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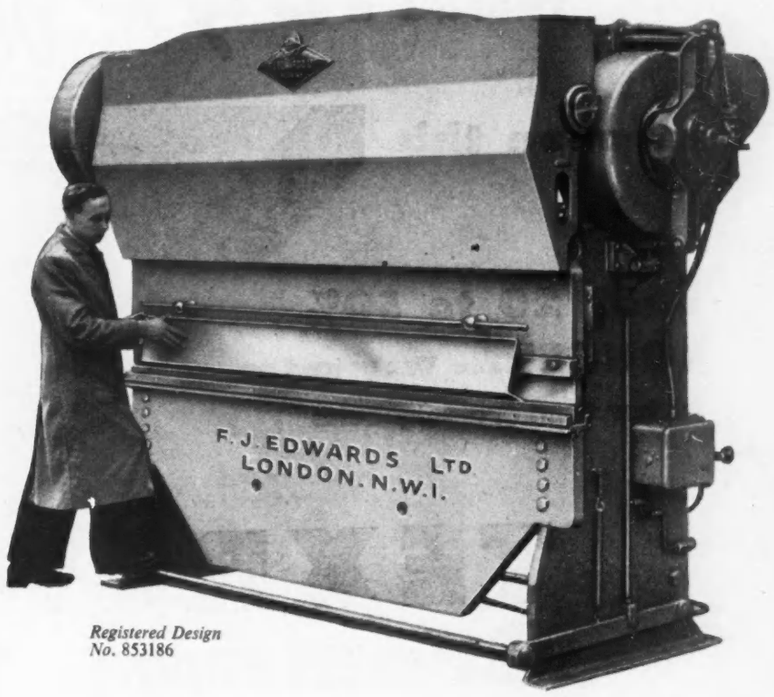

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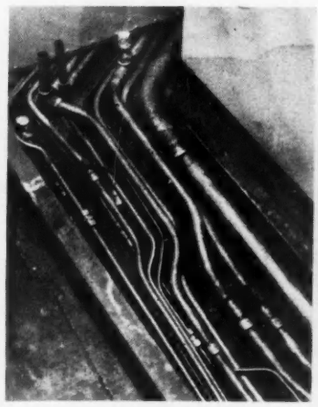

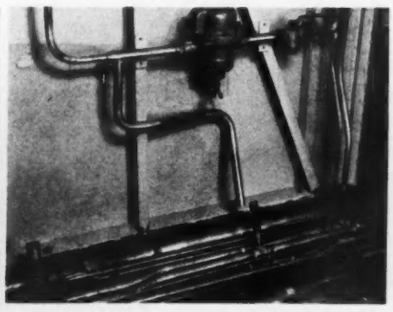

Photographs by courtesy of British Transport Commission

Above : Yorkshire Imperial Copper Tubes and "Yorkshire" Capillary Fittings on air brake and control piping in boiler compartment of British Railways Main-Line Diesel Electric locomotives, Type 2.

Left : Yorkshire Imperial Copper Tubes and "Yorkshire" High Duty and "Instantor" Fittings on air brake and control piping in engine compartment of the above.

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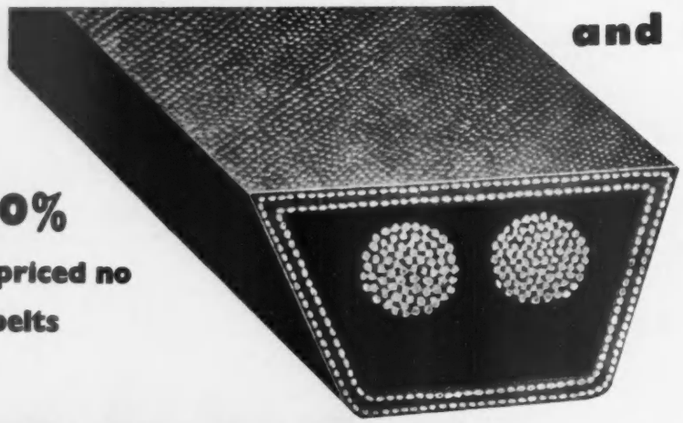
between this  and any other V-belt

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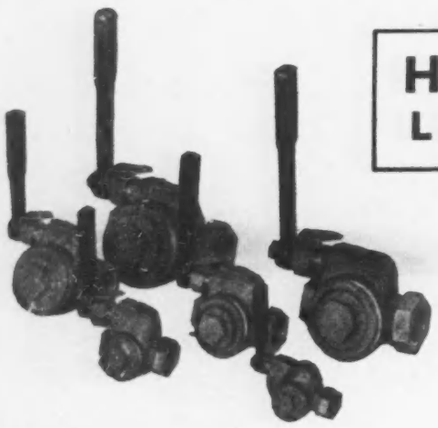

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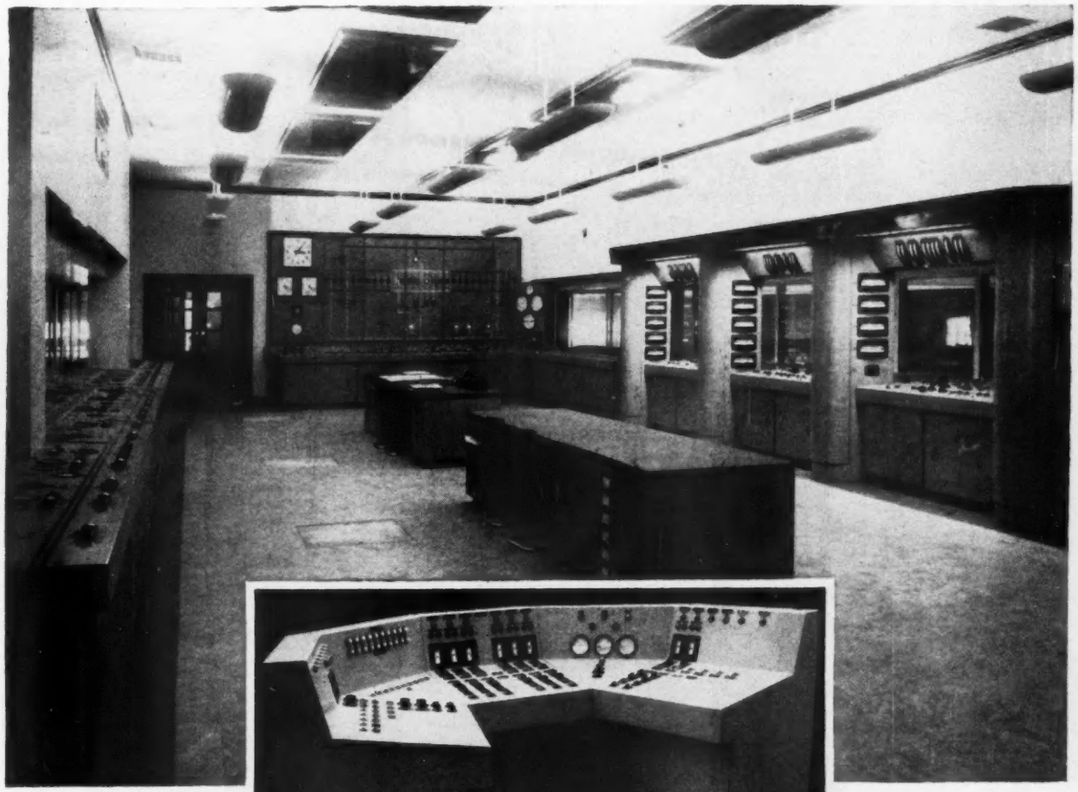
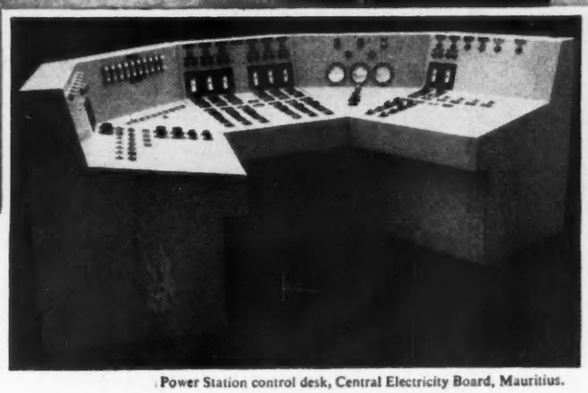


Main Control Room, Ashford Common Pumping Station of the Metropolitan Water Board.



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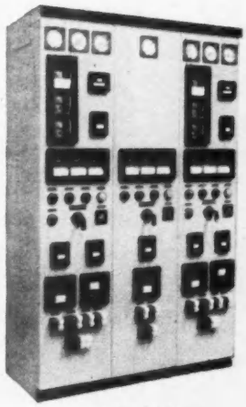

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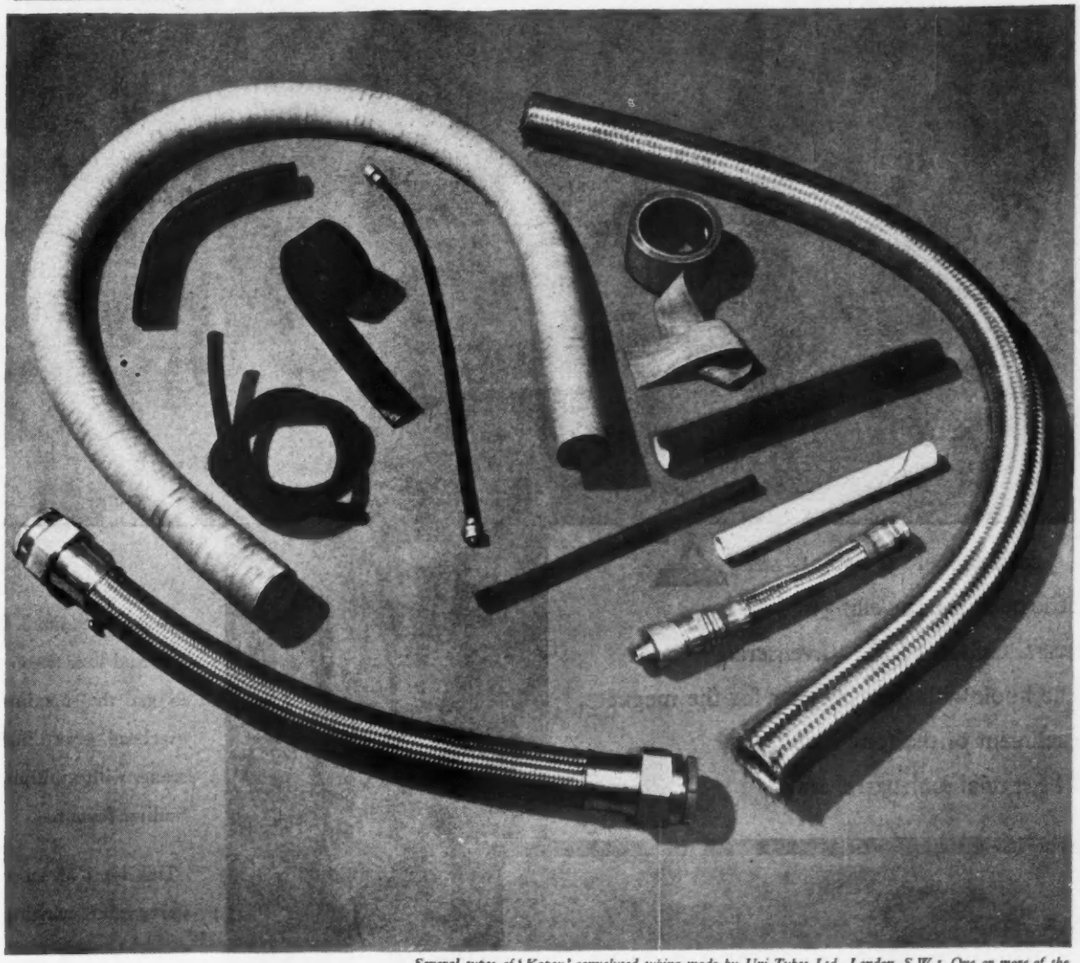

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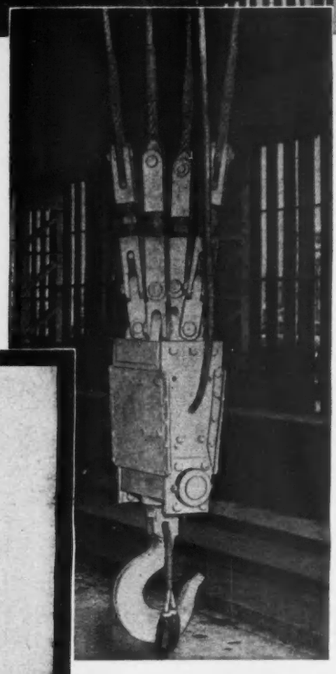
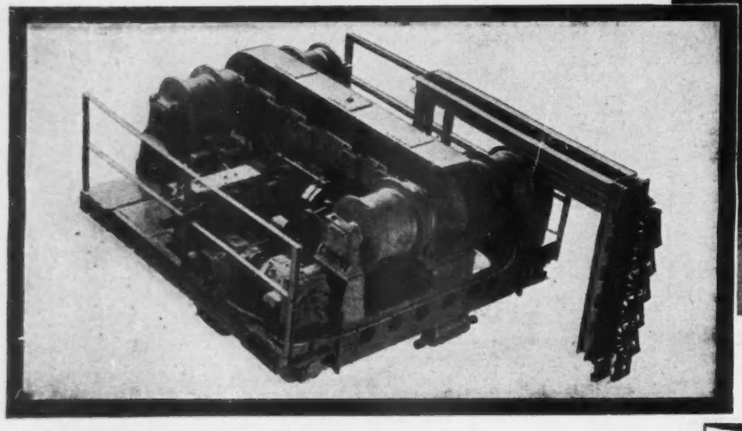
(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.





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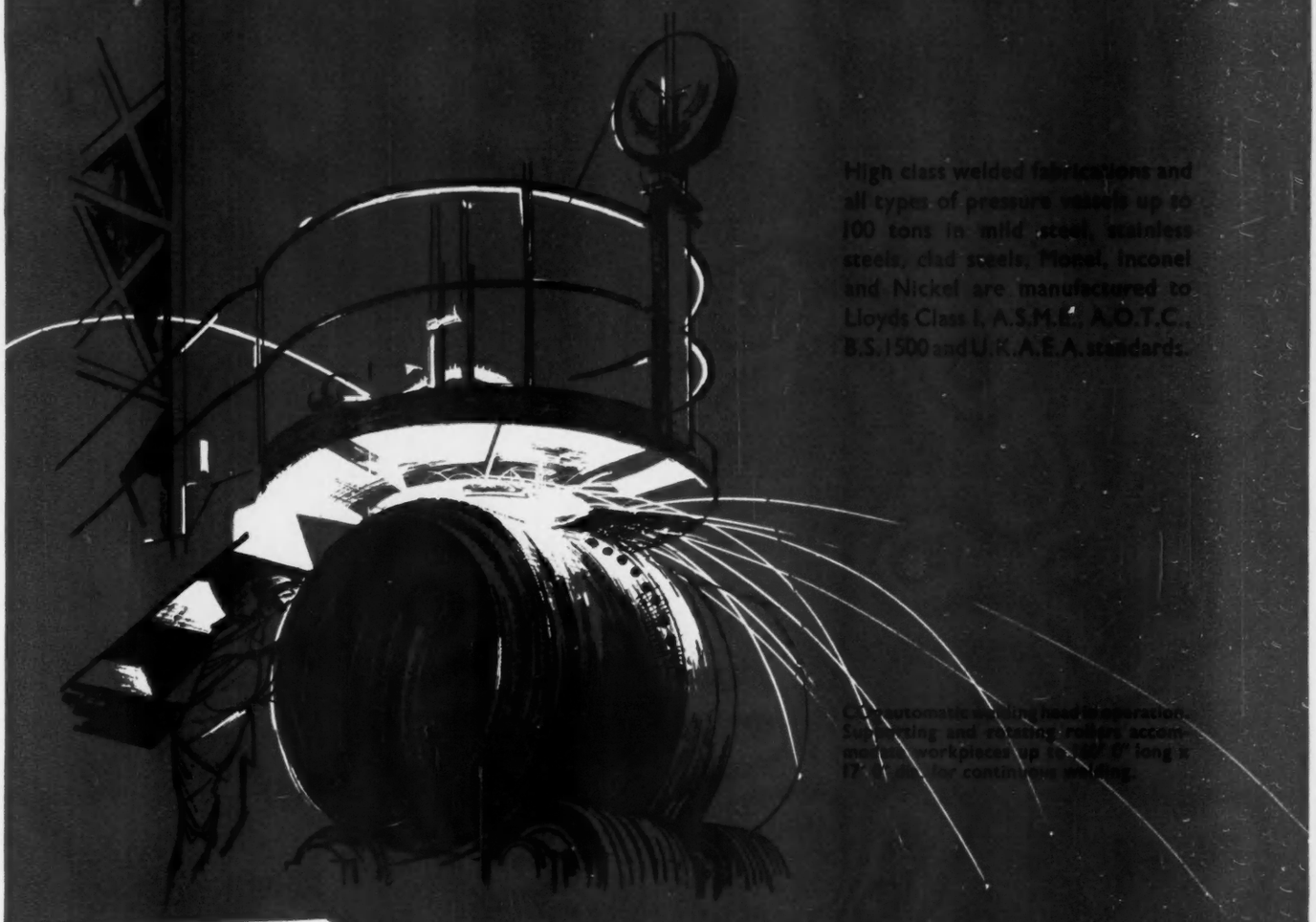

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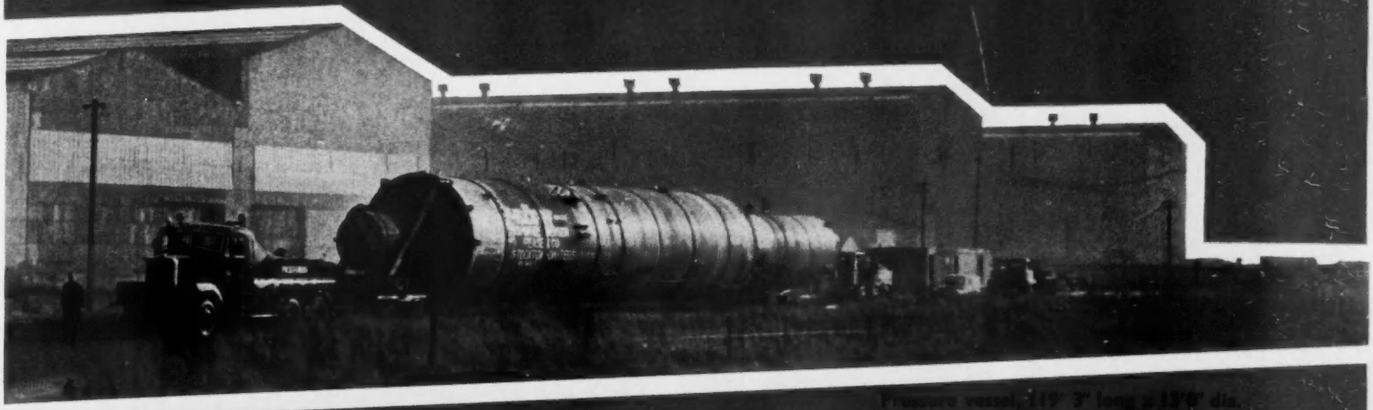

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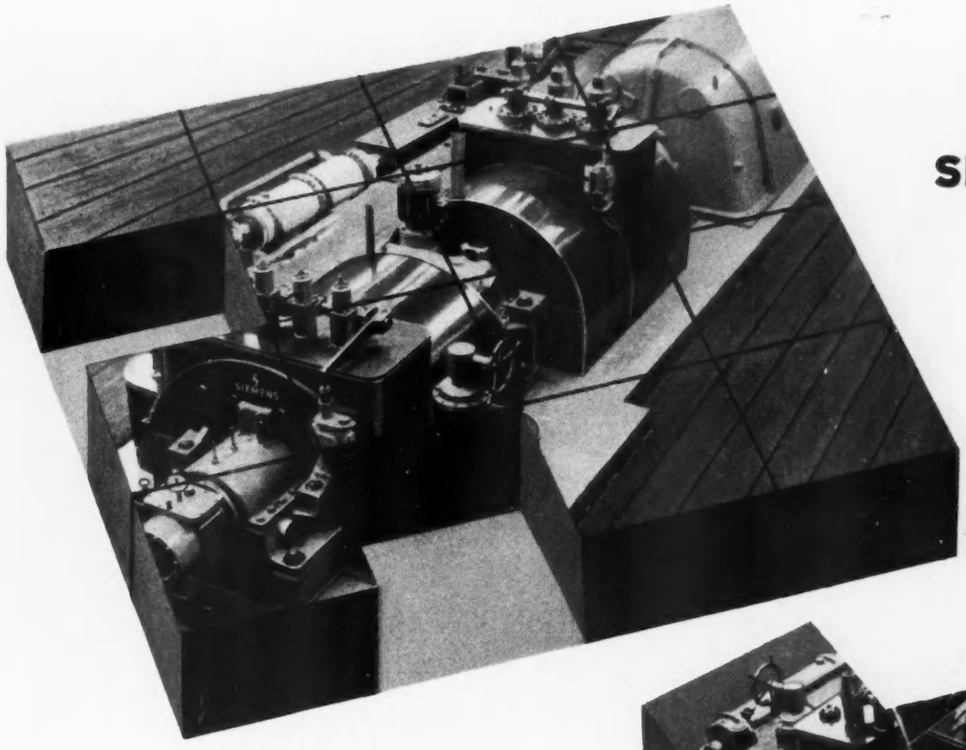

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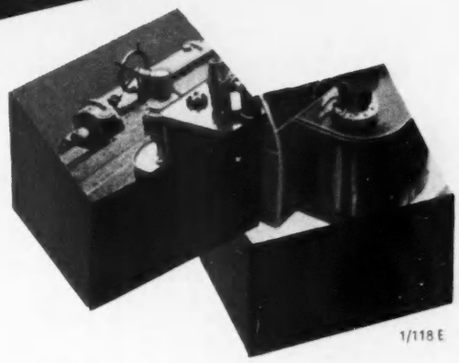

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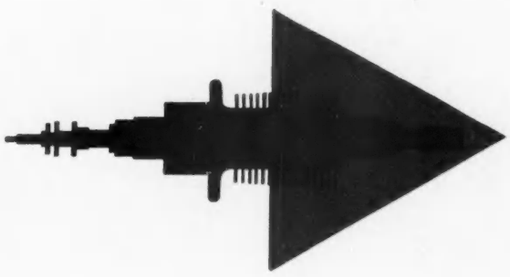

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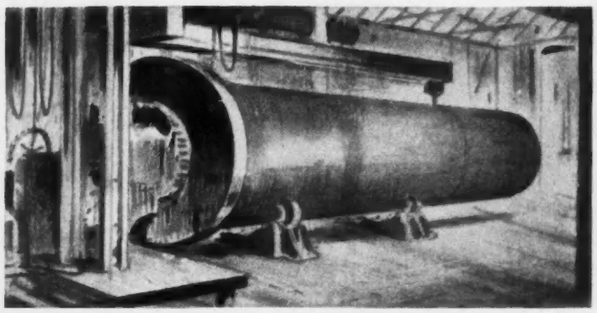
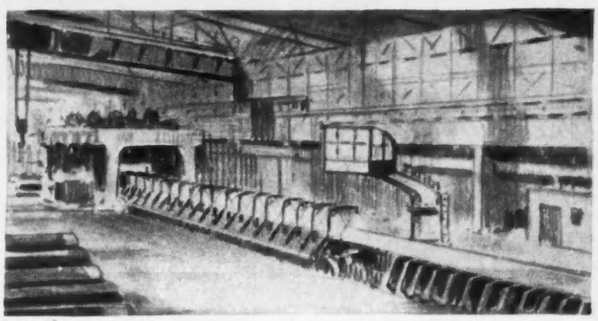
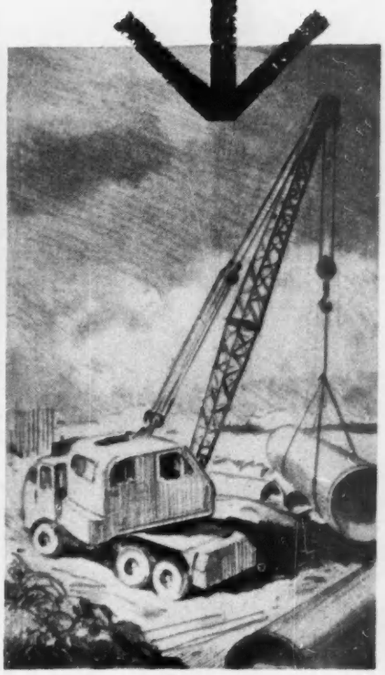






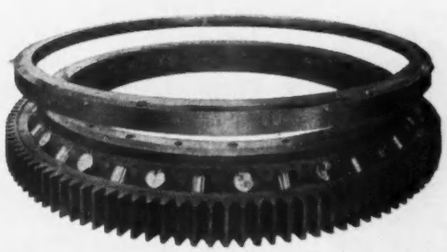
*turn to the Cross-Roll Bearing

Evolved, perfected and manufactured in Great Britain in collaboration with British Timken Limited.

The Priestman Cross-Roll Bearing consists of four separately machined rings. When bolted together in pairs the roller paths form a diamond pattern race section.

The Timken tapered rollers, spaced on the pitch circle by pressed steel cages, alternately contact opposing race surfaces of the outer and inner rings. The crossing of the roller axes in combination with the inclination of the roller paths is the feature that enables the Bearing to resist loads in all directions.

Priestman Cross-Roll Bearings are pre-loaded, pre-lubricated, and sealed self-locating assemblies, requiring no adjustment and little maintenance beyond the periodical replenishment of grease in the labyrinth which supplements the special synthetic rubber cruciform seal, excluding all foreign matter.



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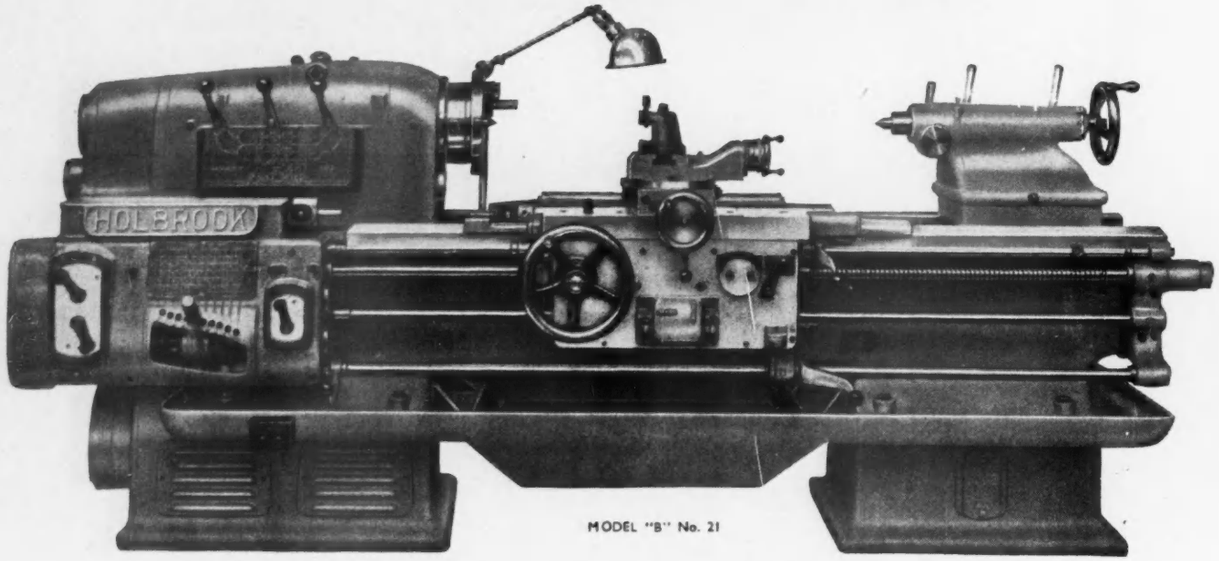

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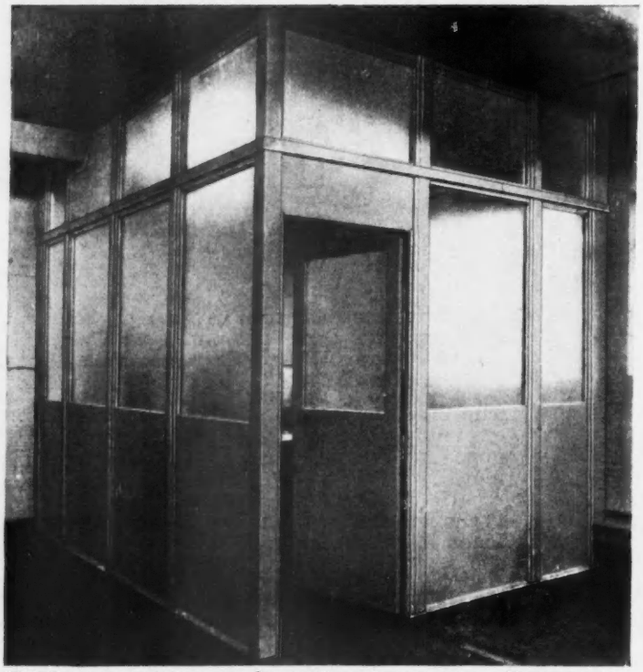

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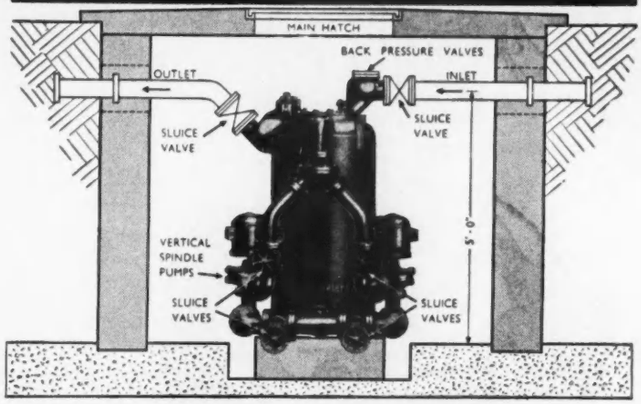

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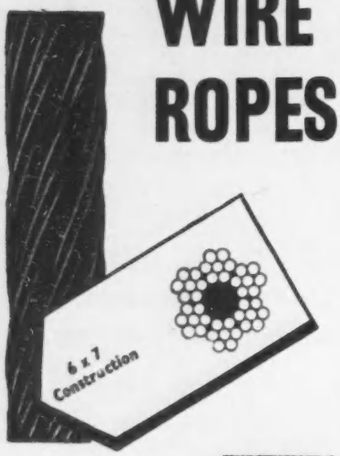

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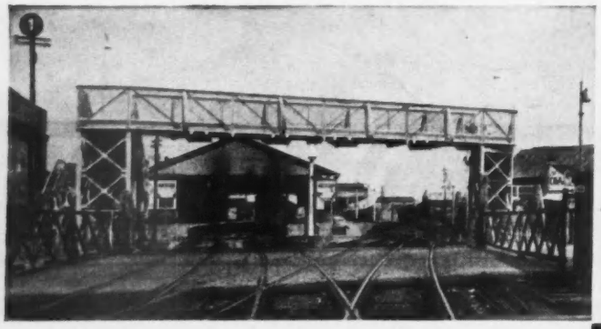

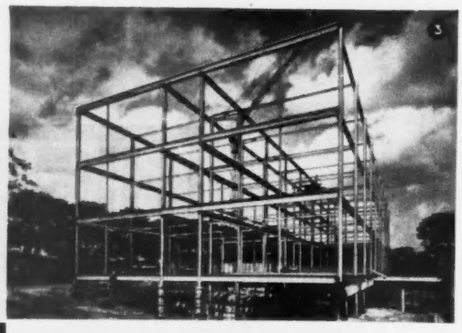

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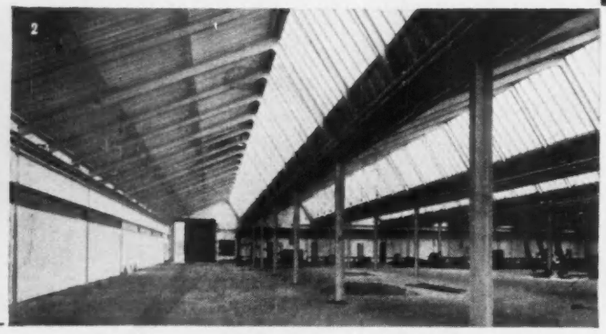

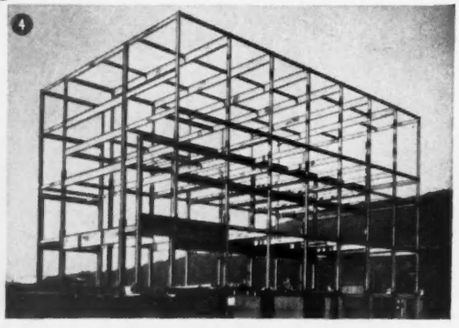

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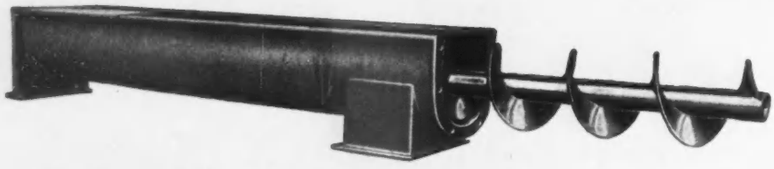

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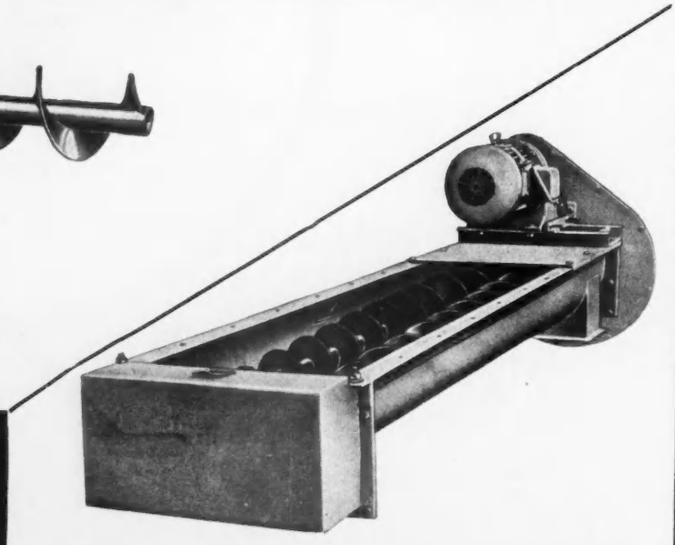

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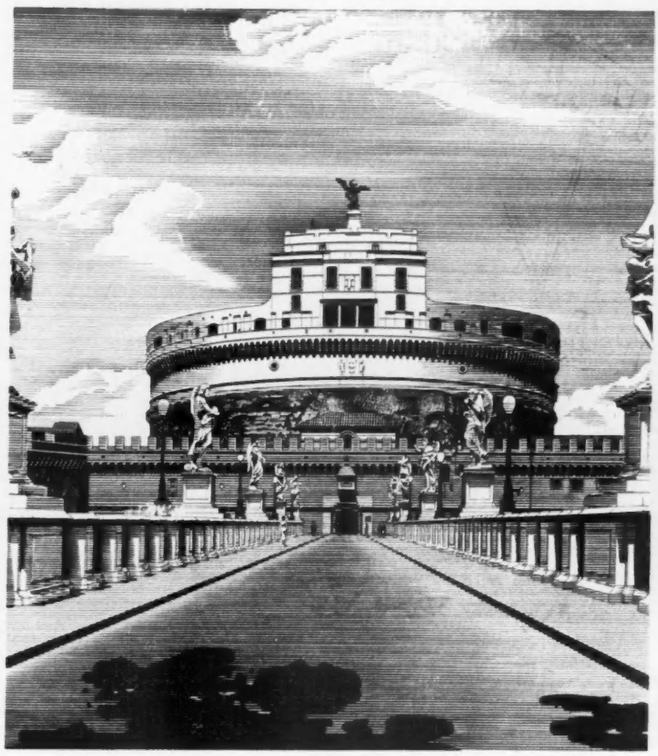

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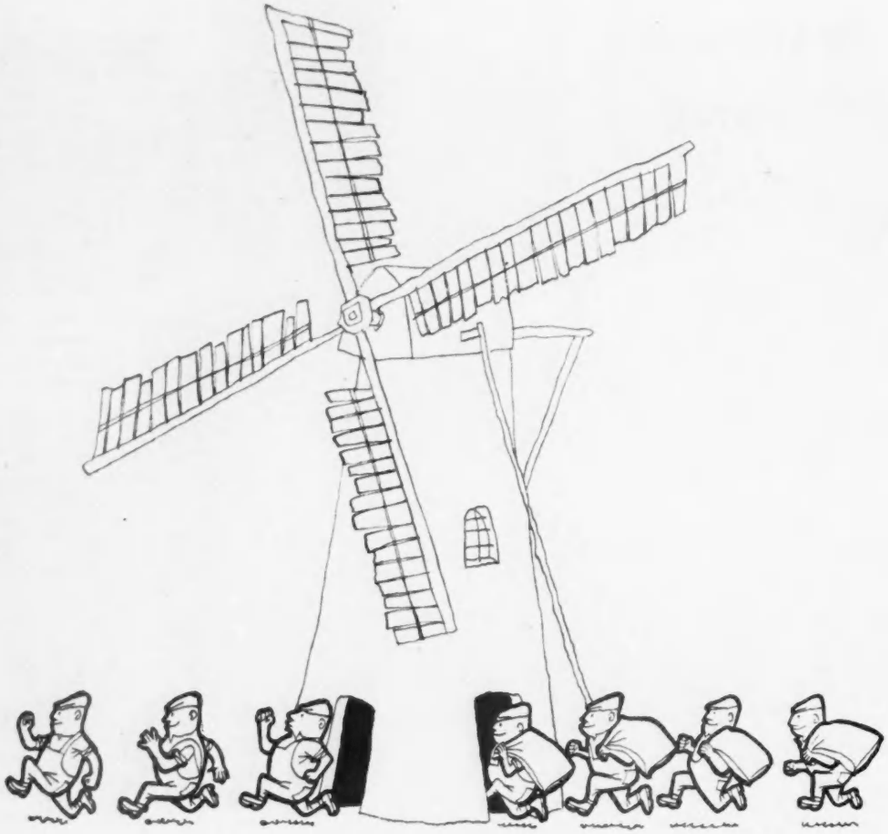

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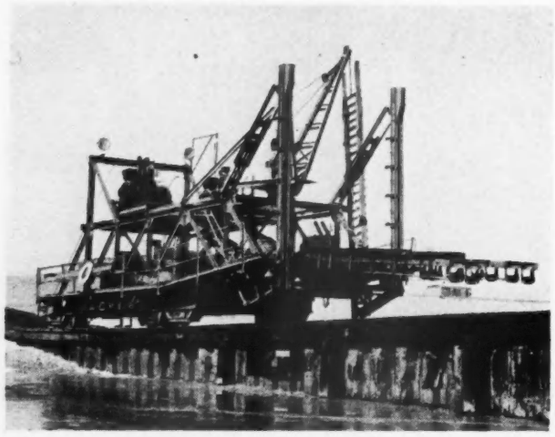

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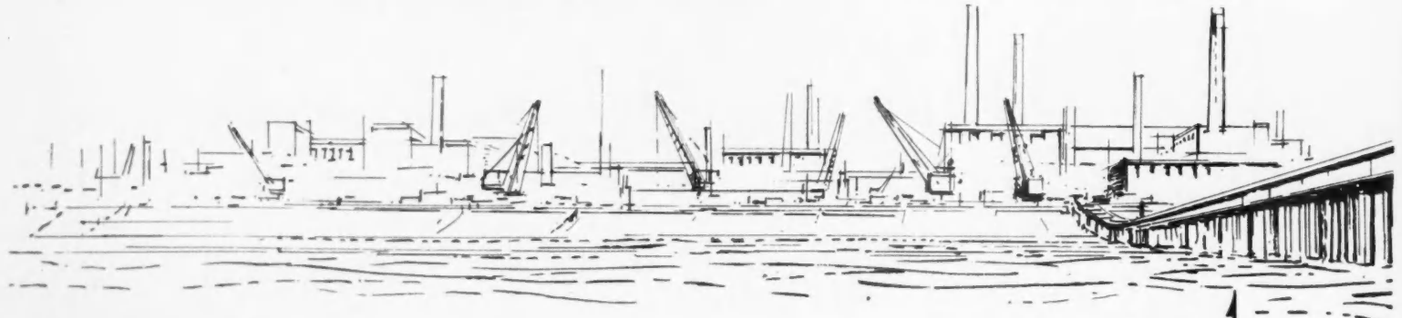

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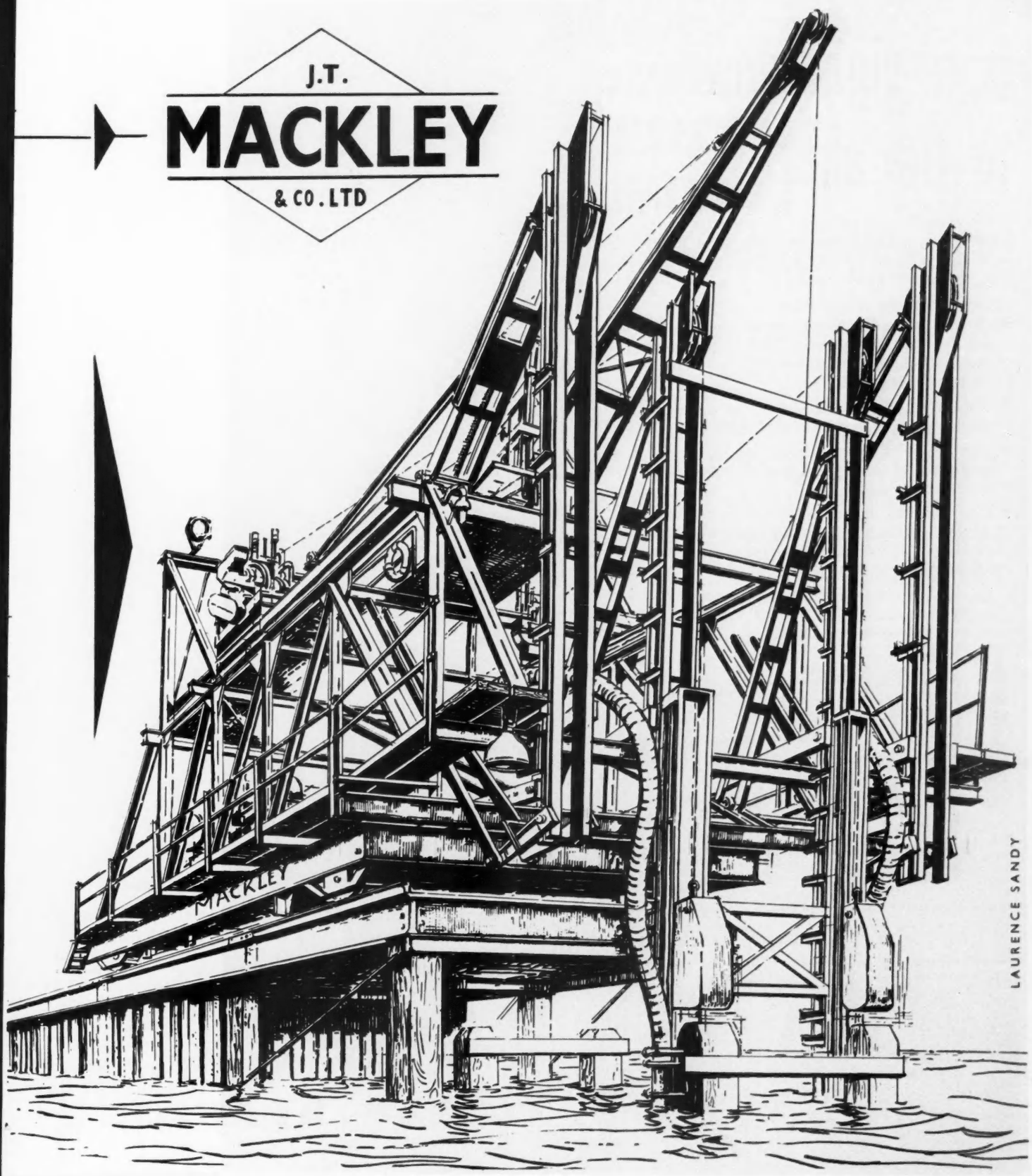

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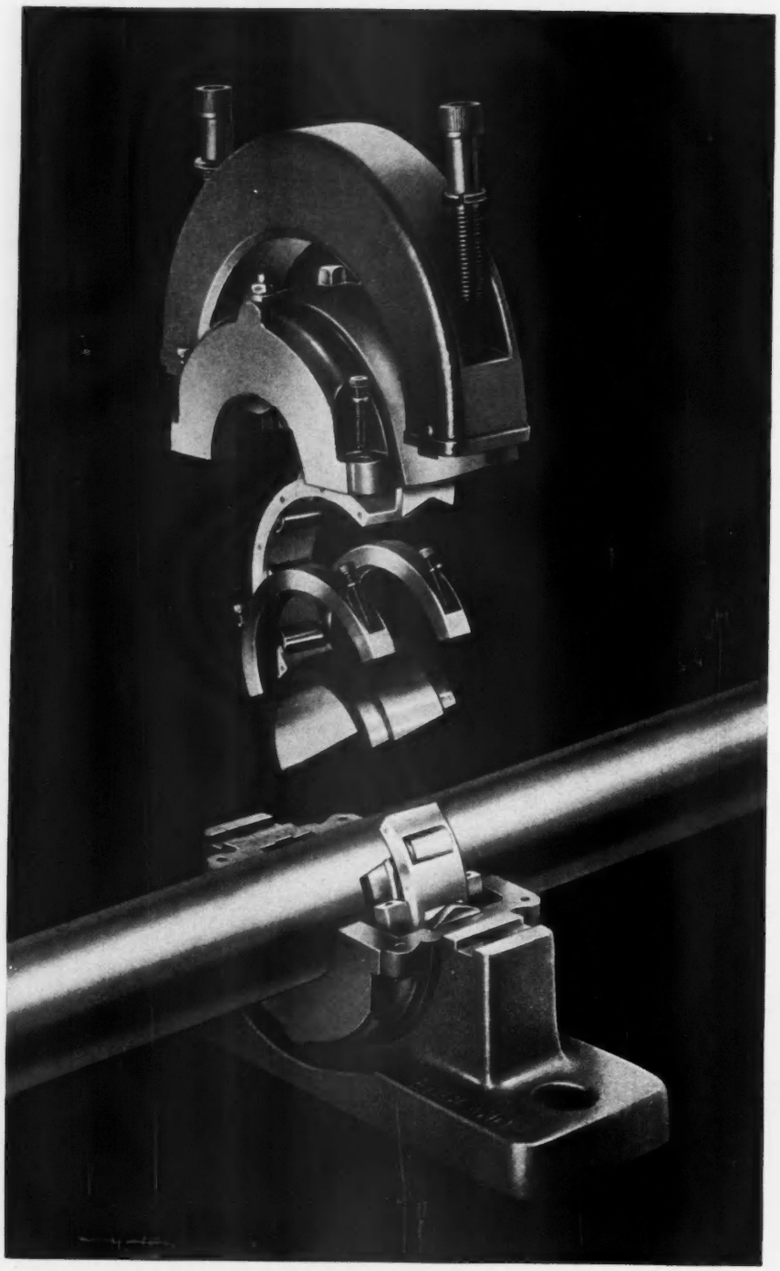

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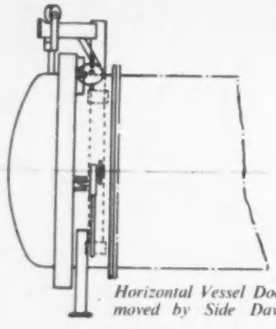
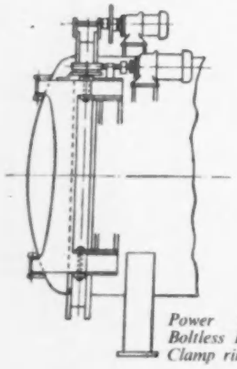
RING CLAMP BOLTLESS DOORS

for vacuum and pressure vessels



Horizontal Vessel Door moved by Side Davit



Power Operated Boltless Door and Clamp ring

Jenkins ring clamp boltless doors offer easy access to all types of pressure and vacuum vessels without impairing sealing efficiency for vessels requiring frequent opening. This brings about a considerable reduction in the cost of labour and increases the speed of operation.

The ring clamp is so arranged that when it rotates, its mild steel clamp tongues engage with corresponding tongues in the door flange. The pressure load on the door is taken entirely by these steel clamps—while a sealing gasket ensures that a positive pressure seal is maintained. The door itself does not rotate so there is no wear on the sealing gasket. A safety locking arrangement provides protection against movement of the ring clamp while the vessel is under pressure.

The small movement of the ring clamp necessary to disengage the door can easily be accomplished by manual operation or by electric, hydraulic, or pneumatic power operation.

The Jenkins ring clamp boltless door is suitable for vertically or horizontally arranged vessels. Ring clamp boltless doors with a short extension shell and bolting flange are available for adapting existing bolted door vessels to this system.

Boltless doors are suitable for Kiers, Sterilizers, Vulcanizers, Impregnating Autoclaves and similar vessels.

THE SIGN OF GOOD WELDING

The latest technical leaflet No. 6A gives full information and is available free on request.

ROBERT JENKINS & CO. LIMITED, ROTHERHAM

Telephone : 4201-6 (6 lines)

Established 1856

56 contracts from the de Havilland AIRCRAFT COMPANY LIMITED for COLT VENTILATION

Time and again, industrialists large and small place repeat orders with Colt. And for three good reasons. Colt ventilation systems depend in the main on internal convection currents—*not* external forces—and are therefore little affected by the vagaries of the wind. Colt offer an unparalleled range of ventilators. And most important, every Colt recommendation is based on a thorough analysis of the building, plant and process either from a site survey or drawings. Such thoroughness influences firms such as the de Havilland Aircraft Co. Ltd. It will impress you, too. Send for a free manual to Dept. S 33 1A

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COMBINED CONVEYING & SCREENING CUTS COSTS OF BULK HANDLING---

PARKER 'Loadascreen'
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Speed up your conveying of all bulk materials where screening into sizes or scalping off of oversize is required. This easily transportable unit handles up to 200 tons an hour, screens into 2 or more sizes, and enables loading and stockpiling to be carried out in one operation.
Save time and labour—write now for Publication No. 545. The Parker 'loadascreen' is available with boom lengths of 40 ft. and 50 ft. and belt widths from 18" to to 36". Petrol, diesel or electric drive. Reciprocating tray feeders and loading traps can be supplied.

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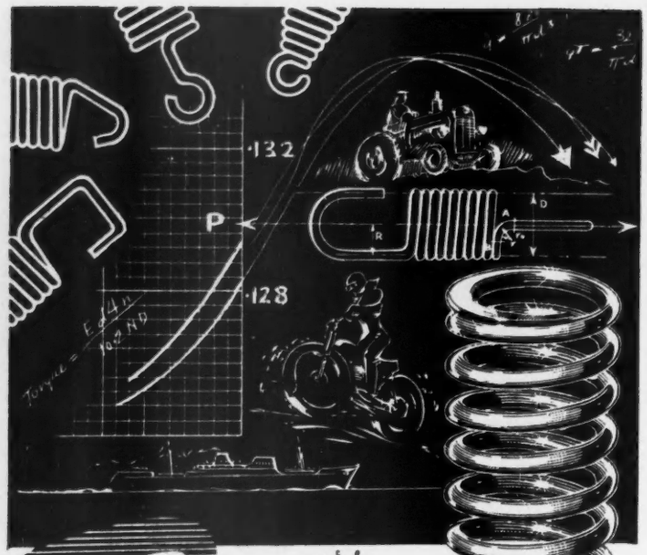
Phones: Leicester 62531 (10 lines) London: Stafford House, Norfolk St., W.C.2.
Depots at London, Cardiff, Sedgley (Staffs.) and Leeds.



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CRAWFORD SPRING WORKS, NORMAN ROAD, ROCHDALE
'Phone: Rochdale 4692/3. 'Grams: Recoil, Rochdale. CW5188

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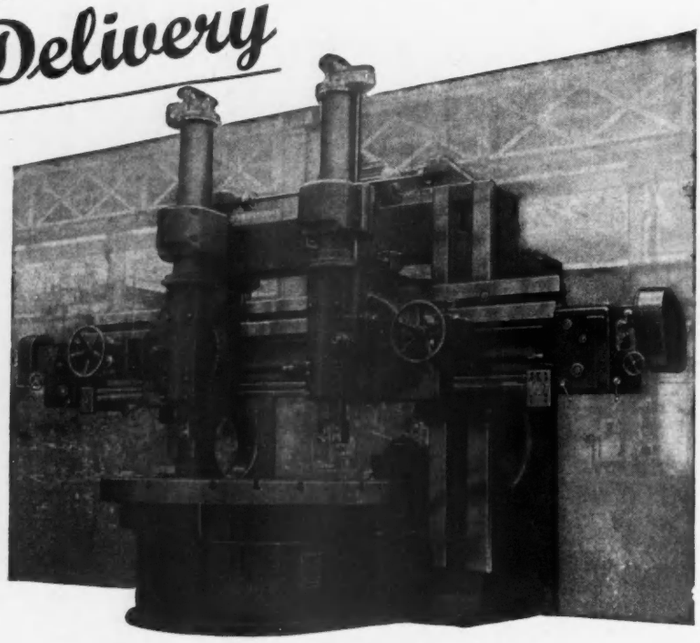

These machines are of heavy construction, each with a 30 h.p. constant-speed table driving motor and a twelve-speed gear box. Feed traverse to each saddle and its ram is by an independent variable-speed motor, and additional constant-speed motors are used for all quick traverse movements.

Duplicate control stations give complete pushbutton operation of the main motor and full selection of the ram and saddle movements, including change-over from feed to quick traverse and vice versa, the various engagements being made by magnetic clutch operation.

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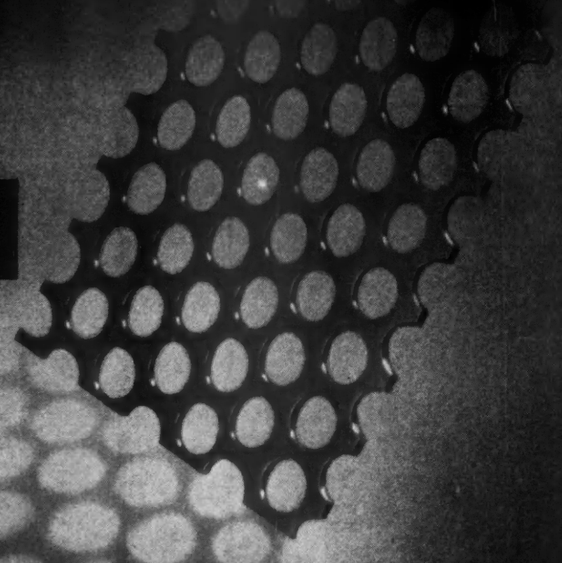

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Globe Works, Queensland Road, Holloway, N.7. Telephone: NORTH 3347/8. Telegrams: Perforation Holway, London

KARIBA at 330 kV.

All the bushing porcelains for
the 330 kV. circuit breakers
All the 330 kV. strain insulators
for the substations
and the 330 kV. post insulators
for some of the substations by

BULLERS

MAIN CONTRACTORS · B.T.H. Co. Ltd.
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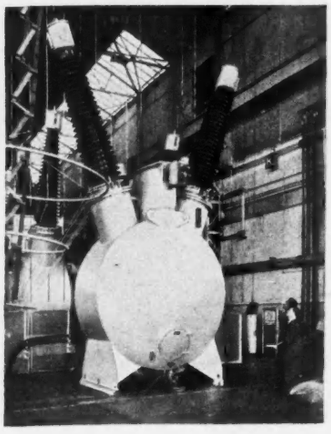
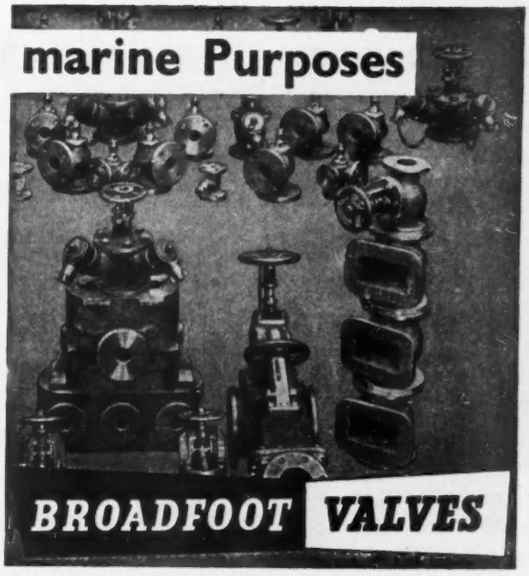


The illustrations show a complete 330 kV. bushing insulator and a 330 kV. circuit breaker, by courtesy of the B.T.H. Co.

BULLERS LIMITED · MILTON · STOKE-ON-TRENT · STAFFS
Telephone: Stoke-on-Trent 54321
London: 6 Laurence Pountney Hill, E.C.4. Tel.: MANsion House 9971

For all marine Purposes



Broadfoot engineering and metal founding has been serving marine engineers for a century. Among the specialities for which the name has long been noted are valves. The range today covers every need—and Broadfoot resources guarantees materials, workmanship and delivery.

Other specialities include tailshaft liners, stern tube bushes, valves, castings up to 8 tons in brass, gunmetal and phosphor-bronze. Also plain and decorative floor coverings in linoleum, cork, rubber, and "Teakoid".

JOHN BROADFOOT & SONS LIMITED
Established 1852
INCHHOLM WORKS, FERRYDEN STREET, WHITEINCH, GLASGOW, W.4.
ON ADMIRALTY, AIR MINISTRY, WAR OFFICE & COLONIAL OFFICE LISTS

Electrically Butt Welded Steel Pipe and Specials from 7 in. to 72 in. diameter by Alfred Allen.

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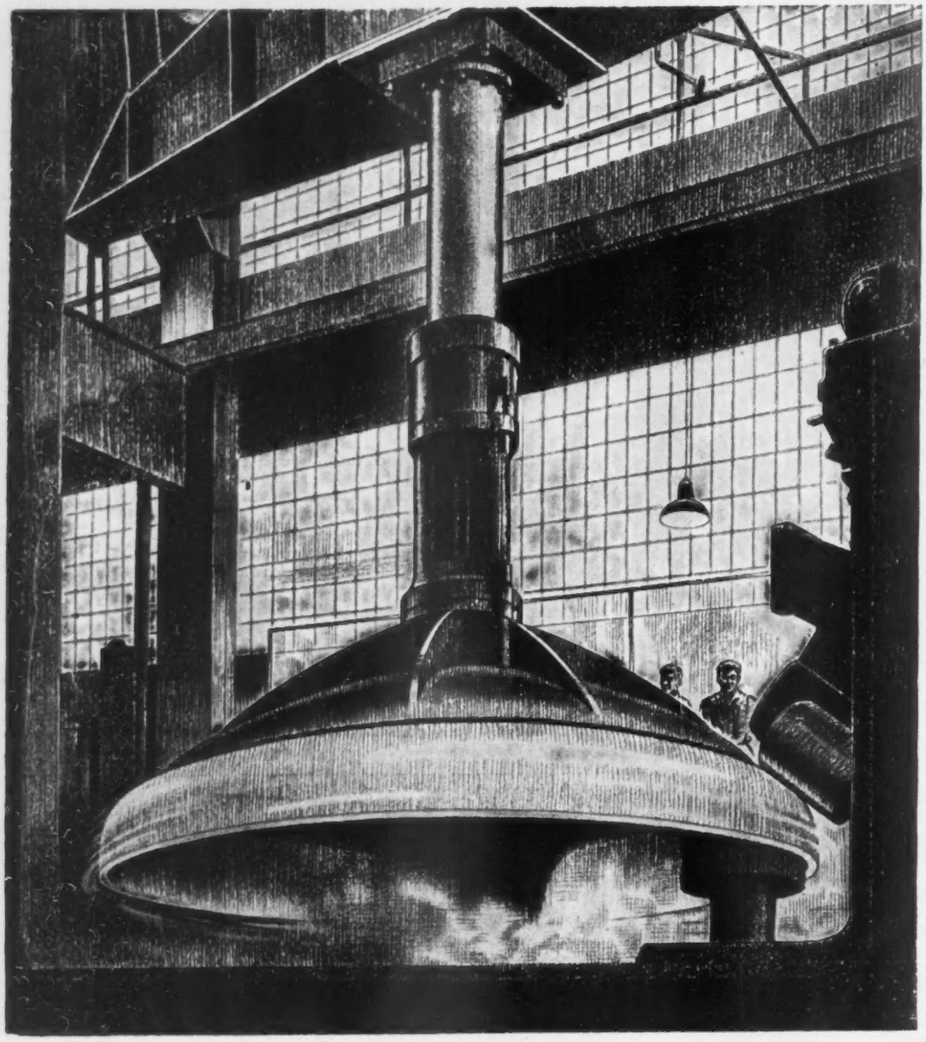

The design and production of Pressure Vessels may be greatly facilitated by using dished and flanged ends spun by Harveys on the Rotarpress. They combine semi-ellipsoidal form with large knuckle radius. A substantial reduction in plate thickness can be effected, and in most cases tool costs are eliminated.

'Rotarprest' Ends for Pressure Vessels

can be supplied in Mild, Alloy and Clad Steels, and Non-ferrous Metals. The capacity of the Rotarpress ranges from 5 to 15 feet diameter, and $\frac{3}{8}$" to 4" thickness; knuckle radii and depth may be varied to meet individual requirements.

Please ask for List No. E965 giving full range of sizes.

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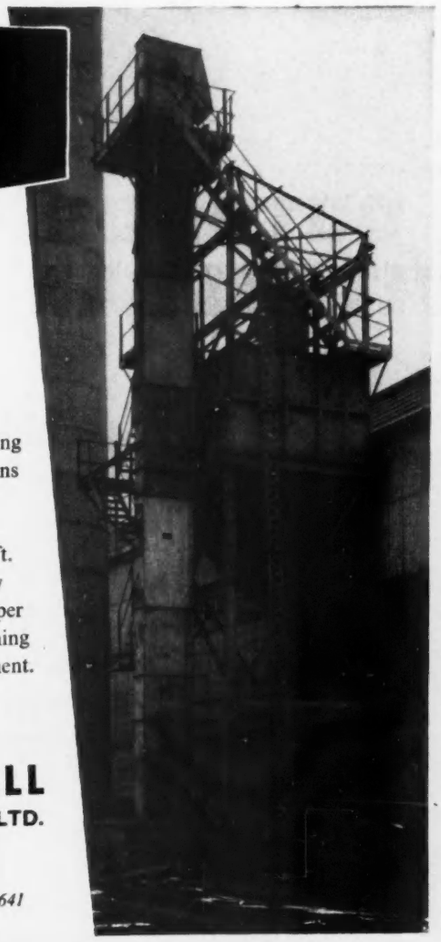
A COKE PLANT

This is a complete crushing and screening plant handling 15 tons of coke per hour, comprising belt and bucket elevators 80 ft. high, 30 ton capacity storage bunker, scraper conveyor with screening and crushing equipment.



Designed, manufactured and erected by

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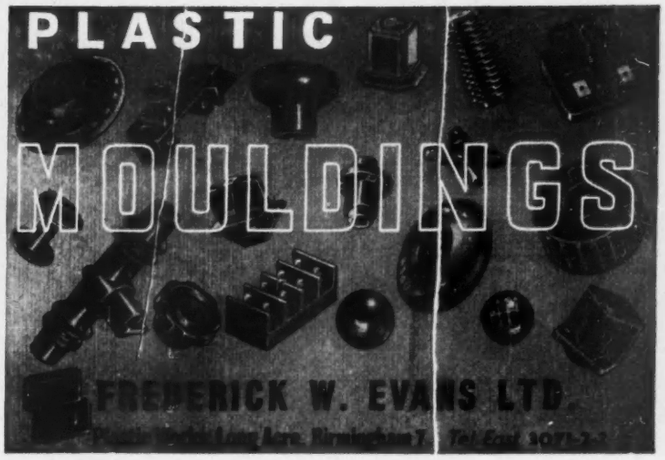
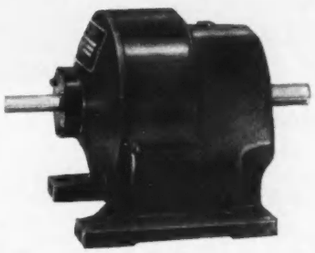


NECO TRADE MARK

geared SPEED REDUCERS

Neco speed reducers are used where speed reduction is required between two operating shafts. They can be used with an electric motor when a clutch must be fitted between motor and gearbox.

All transmitted torque and horsepower and output speeds listed are based on an input speed of 1400 r.p.m.

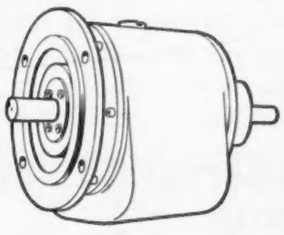


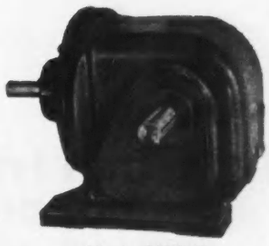
straight line drives

TYPE DS (illustrated)	Up to ½ h.p. or up to 100 lb. ft. torque. 0·5 to 475 r.p.m.
TYPE 25	Up to ⅛ h.p. or up to 25 lb. ft. torque. 0·079 to 312 r.p.m.
TYPE HD	Up to 2 h.p. or up to 200 lb. ft. torque. 0·62 to 480 r.p.m.
TELE SPEED REDUCERS	Up to 1500 lb. ft. torque. 0·12 to 12·75 r.p.m.

flange mounting

Types 25, DS and HD speed reducers can be supplied with flange mounting instead of feet to enable the unit to be accurately bolted to your machine.





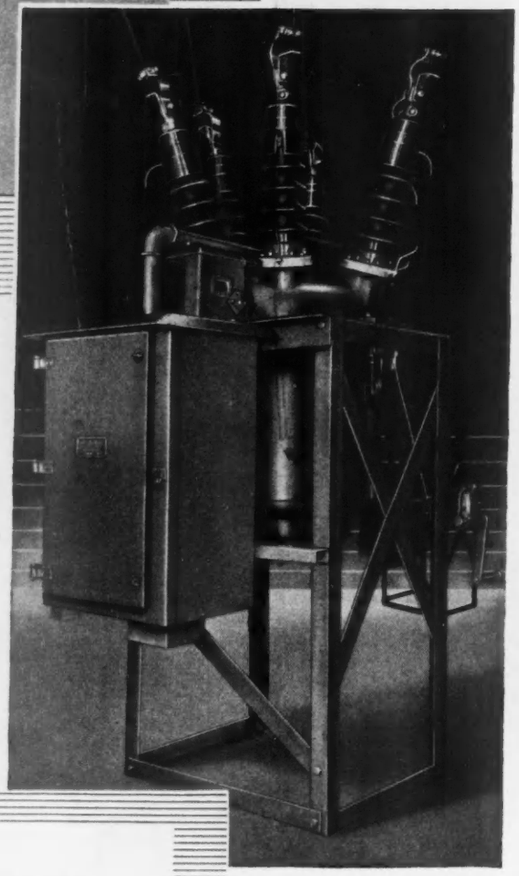
(Rd. No. 888,830)

right-angle drives

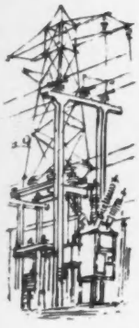
TYPE DR (illustrated)	Up to ½ h.p. or up to 100 lb. ft. torque. 4 to 305 r.p.m.
TYPE SW	Up to ⅛ h.p. or up to 25 lb. ft. torque. 0·055 to 270 r.p.m.

NECO GEARED MOTORS LIMITED · 204 QUEENSTOWN ROAD · LONDON · S.W.8
Subsidiary of Normand Electrical Co. Ltd. *Telephone: MACaulay 3211-4*

Why TYPE ROP 32 OUTDOOR SWITCHGEAR ?



Readily adaptable to particular system requirements



FOR 22/33 kV SERVICE

When a decision must be reached concerning the installation of new, or replacement, OUTDOOR Switchgear the question may well be asked,

"WHY CHOOSE TYPE ROP. 32?"

For the very good reason that this class of switchgear has acquired a high reputation for itself for giving reliable service in many parts of the World, and in varied climatic conditions.

AEI

Manufactured at the Higher Openshaw Works of

Associated Electrical Industries Limited

SWITCHGEAR DIVISION

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F774

WEAR RESISTING CASTINGS
for **SAND & GRAVEL PUMPS**

by

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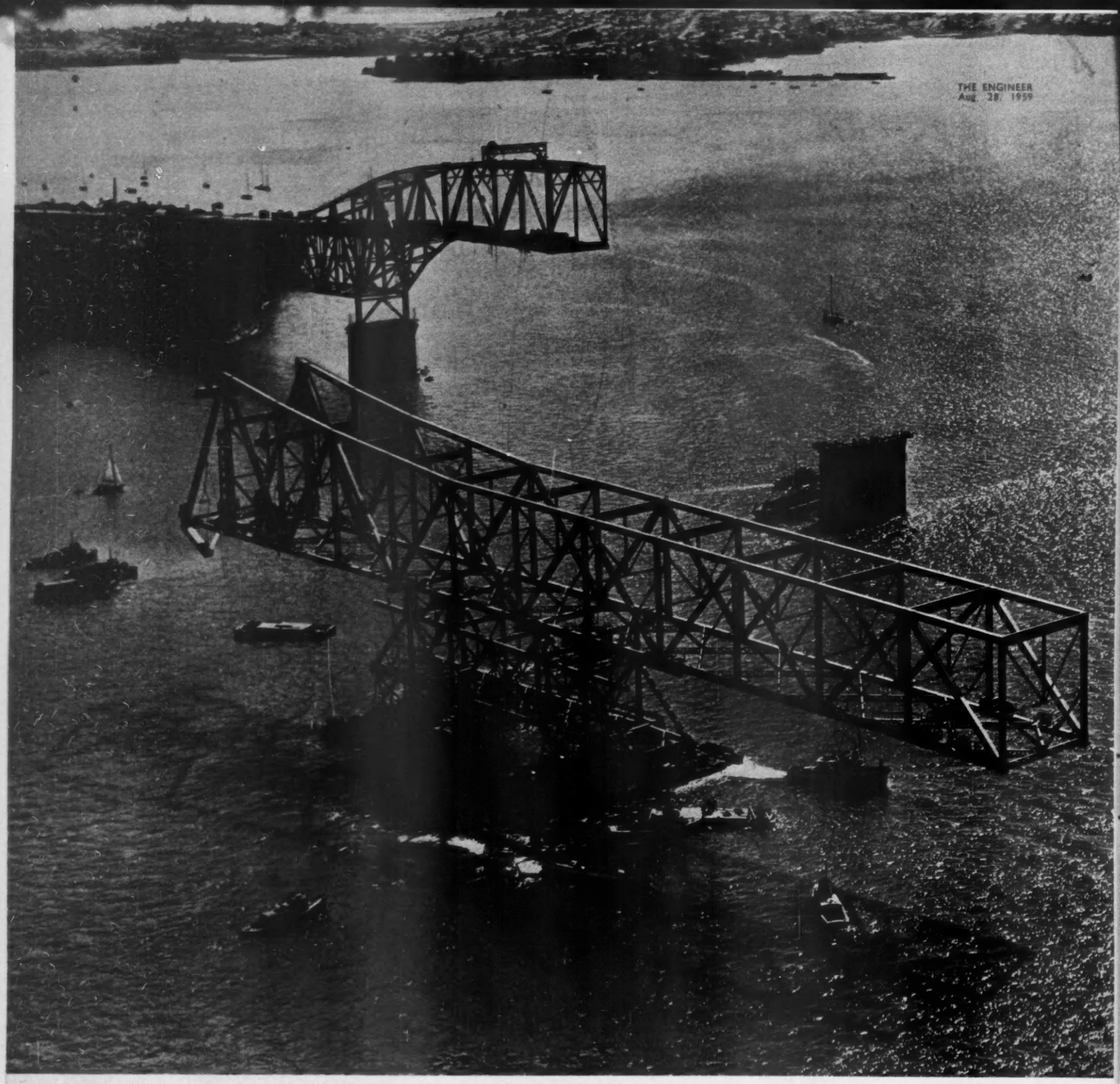

Whites Aviation photograph

Floating-in a 580ft. span of the AUCKLAND HARBOUR BRIDGE

Consulting Engineers: Freeman Fox & Partners

DORMAN LONG

in partnership with

THE CLEVELAND BRIDGE AND ENGINEERING CO. LTD

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Economies made possible with CUSHYFOOT MOUNTINGS

Metalastik Cushyfoot mountings have proved outstandingly successful in their effective isolation of shocks and vibration arising from all types and size of machines.

If Metalastik Cushyfoot mountings are used, many machines can be mounted on lighter foundations, just enough to support the dead load without consideration of dynamic forces.

In many cases the large 'inertia' blocks of concrete, so often used, can be dispensed with, or greatly reduced in mass.

'A' AND 'B' SERIES

For loads of 200-3,500 lb. per mounting with deflections up to ¼", Cushyfoot mountings provide different degrees of flexibility according to the direction of the load but can be disposed to give the same resilience in all directions.

HIGH DEFLECTION SERIES

With characteristics similar to 'A' and 'B' types but double the deflection, this series is especially suitable for machines in the lower speed range. Deflections up to 1" can be obtained by fitting two mountings, one above the other.

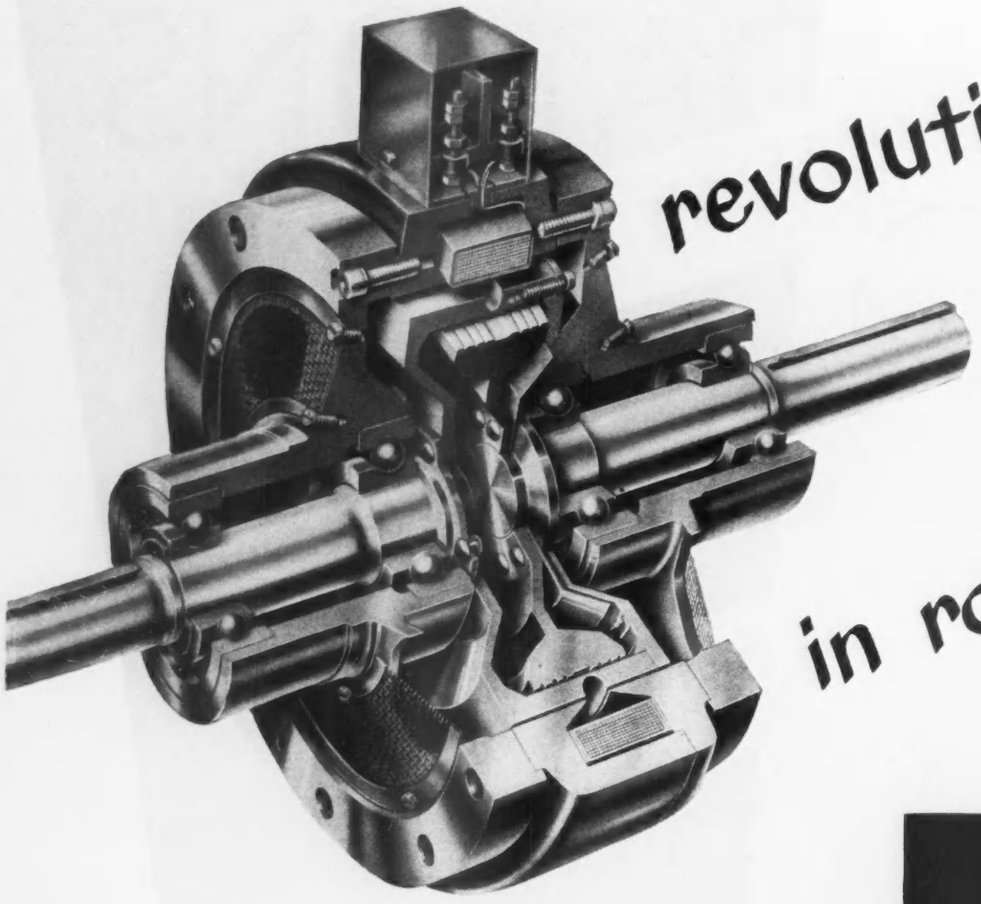
FRICTIONAL LOCATION

Cushyfoot mountings can be supplied with frictional locating pads which obviate bolting down.

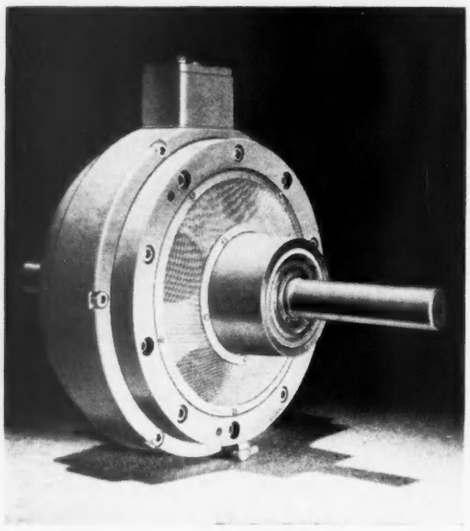
Full particulars of Cushyfoot mountings on application.

METALASTIK

METALASTIK LTD.,
LEICESTER



revolution in rotation



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Magnetic Particle COUPLING

This is a positive coupling working on a new principle. It is NOT a magnetically operated clutch, and there are no plates to wear.

Driving and driven members are coupled by magnetically activated particles, giving perfectly smooth take-up and accurate control of torque. Eight standard units are made ranging from 1/3 to 200 lb/ft.

SMITHS S. SMITH & SONS (ENGLAND) LIMITED

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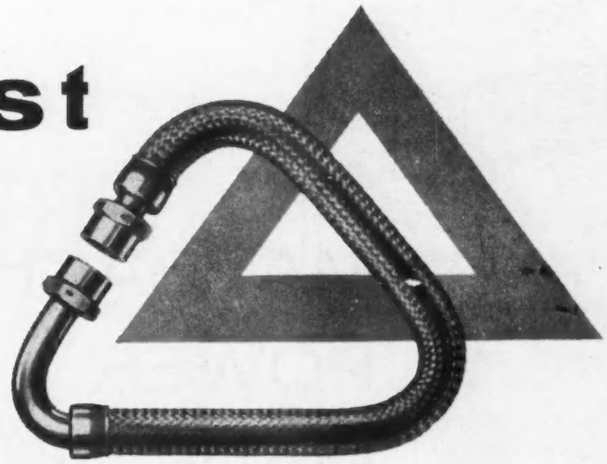
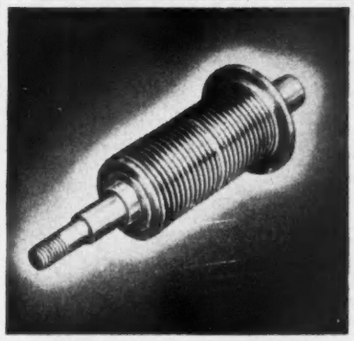
INDUSTRIAL PRODUCTS DEPARTMENT, WITNEY, OXON · Telephone: WITNEY 678

safety first

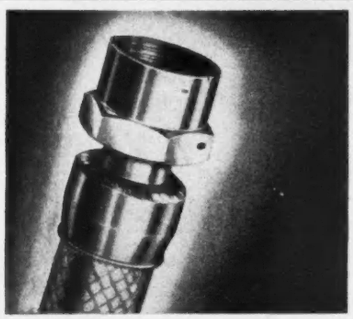




AVICA-FLEX

BELLOWS

(*including precision barometric units*, with closely controlled spring rate tolerances). For use in gas and fluid ducting systems for control of expansion or contraction, and to allow for misalignment. Other uses include shaft seals and glands. Available in stainless steel and other metals.



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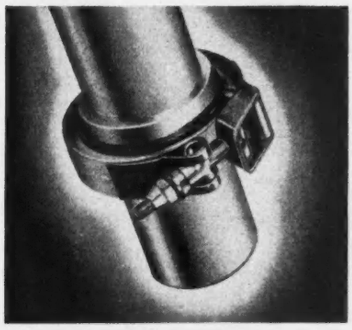
STAINLESS STEEL FLEXIBLE PIPE ASSEMBLIES

For conveying gases and corrosive fluids at temperatures from −196°C to as high as 450°C. Available from ¼" up to 4" diameter.

specify **AVICA** flexible assemblies and components

Where pressures or temperatures reach unusual extremes and vibration may be severe, take no chances—insist on AVICA pipe assemblies and components. Tested and proved by 20 years of service and used by the U.K.A.E.A. and throughout the nuclear engineering field, AVICA products are renowned for absolute dependability. Any problem of piping design or installation can safely be entrusted to Avica engineers.

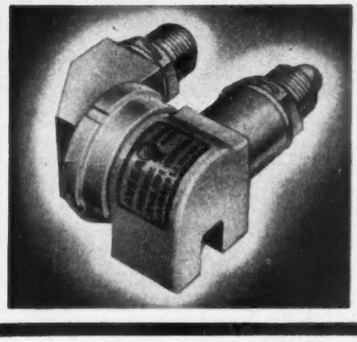


RIGID TUBE COUPLINGS

With mechanically attached V Flange or bolted flange connections. No welding. No brazing. Leak-proof. Pressure tight. Will withstand extremes of temperature and vibration

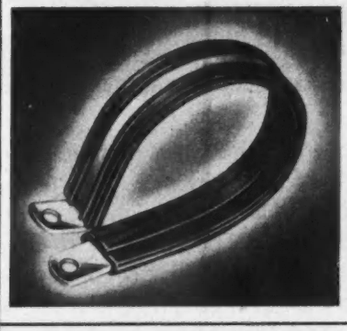
SYNTHETIC RUBBER FLEXIBLE PIPE ASSEMBLIES

Used to carry petrol, oil, air, steam, hydraulic fluids, for machine tools, hydraulic presses, mining equipment, at pressures up to 3,000 p.s.i. Size range ¼"—2". Temperature range −40°C to 160°C.



SWIVEL PIPE COUPLINGS

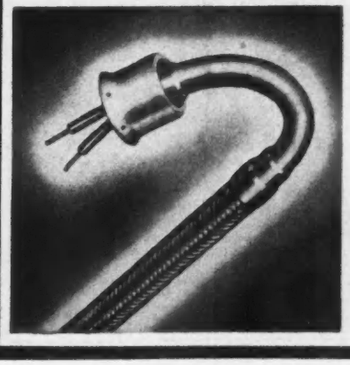
To provide rotary or angular movement in rigid or flexible pipe systems. In pipe sizes up to 1" for pressures up to 4,000 p.s.i.



SUPPORT CLAMPS

To hold piping and electrical cables. The rubber cushion absorbs vibration, can be renewed when worn or perished.

Illustrated leaflets describing the full range of AVICA products are available on request. Please write for those that interest you.



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Electrical wiring protected by rigid or flexible conduit from heat, oil, moisture and vibration.

AVICA

AVICA EQUIPMENT LIMITED

MARK ROAD · HEMEL HEMPSTEAD · HERTS

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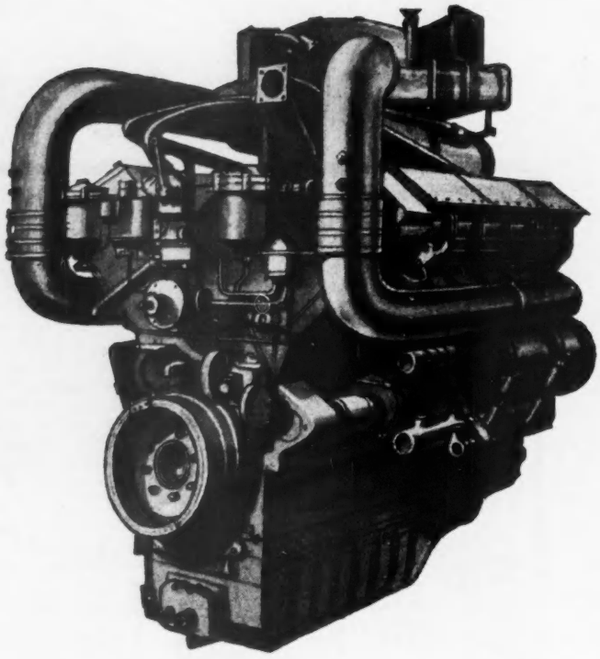
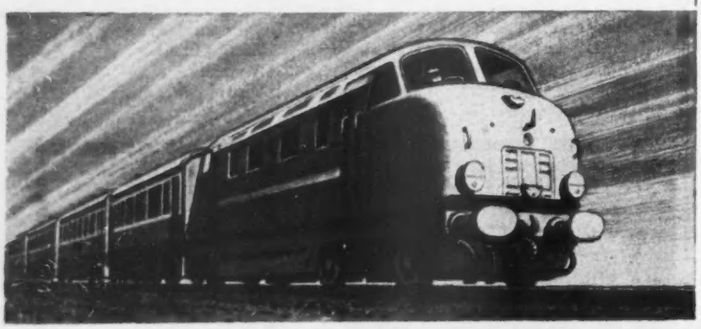
MAYBACH POWER MADE IN BRITAIN



Typical of the MD range of engines is this Type 650 12 cylinder supercharged model with cylinders arranged in 'V' formation.



◀ Railway Traction 220-2,000 B.H.P.

Industrial Plant 220-1,750 B.H.P. ▶

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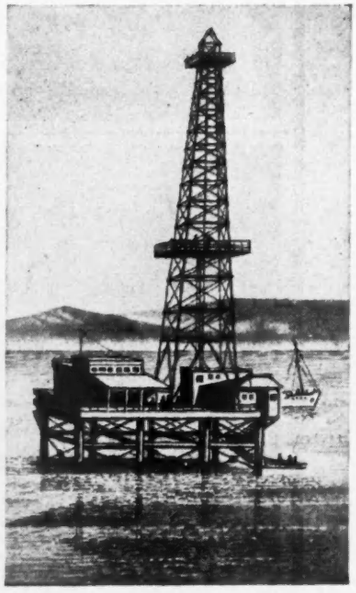

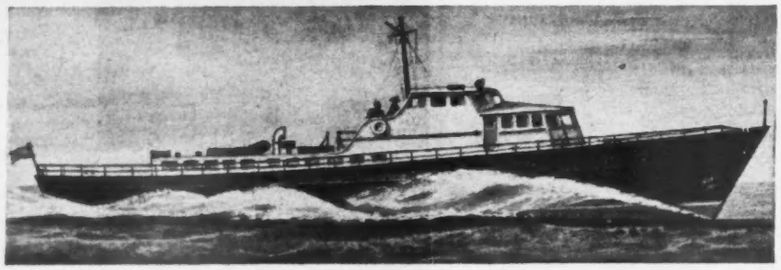

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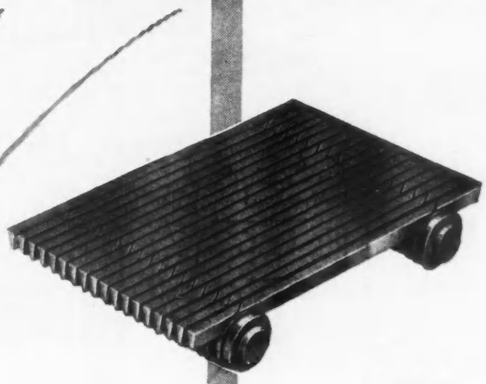

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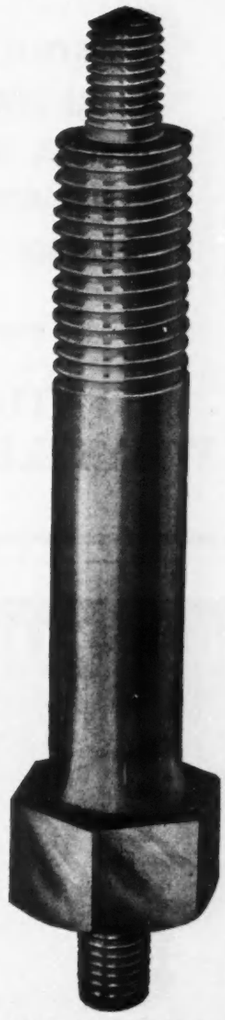

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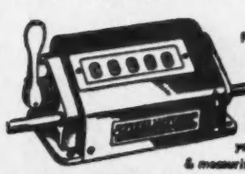

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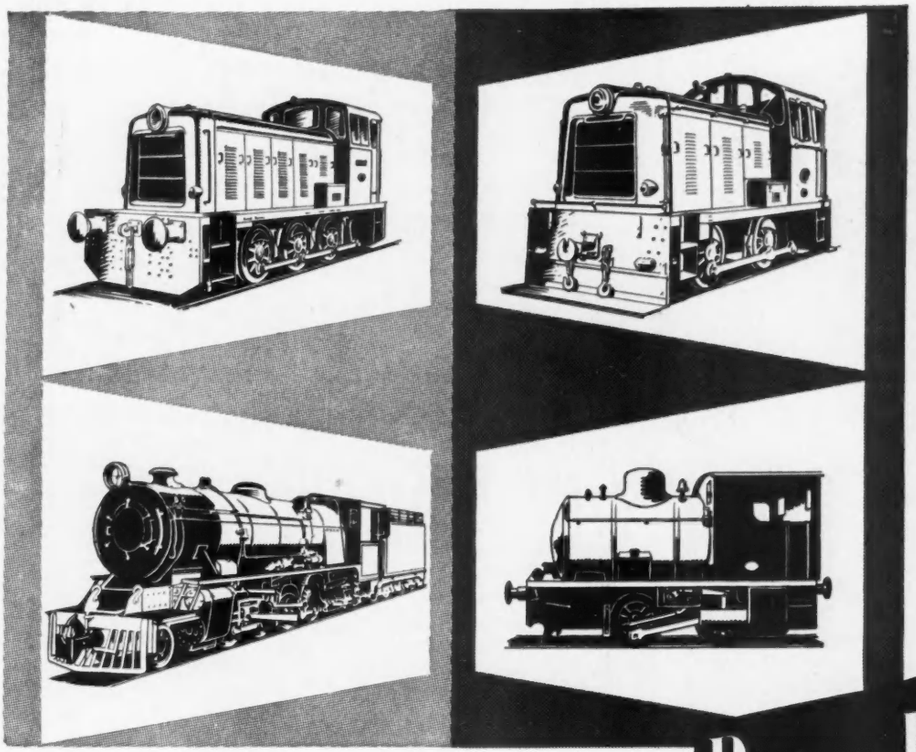

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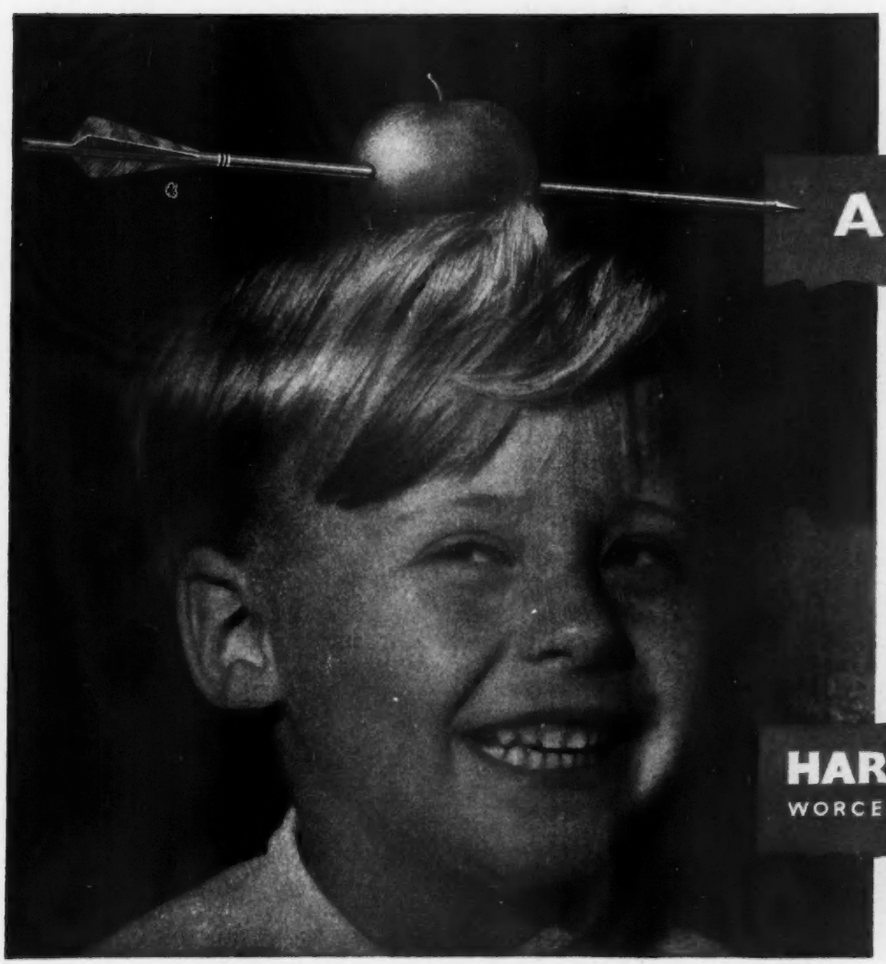

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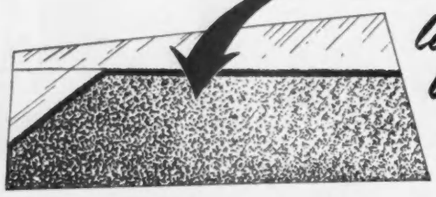

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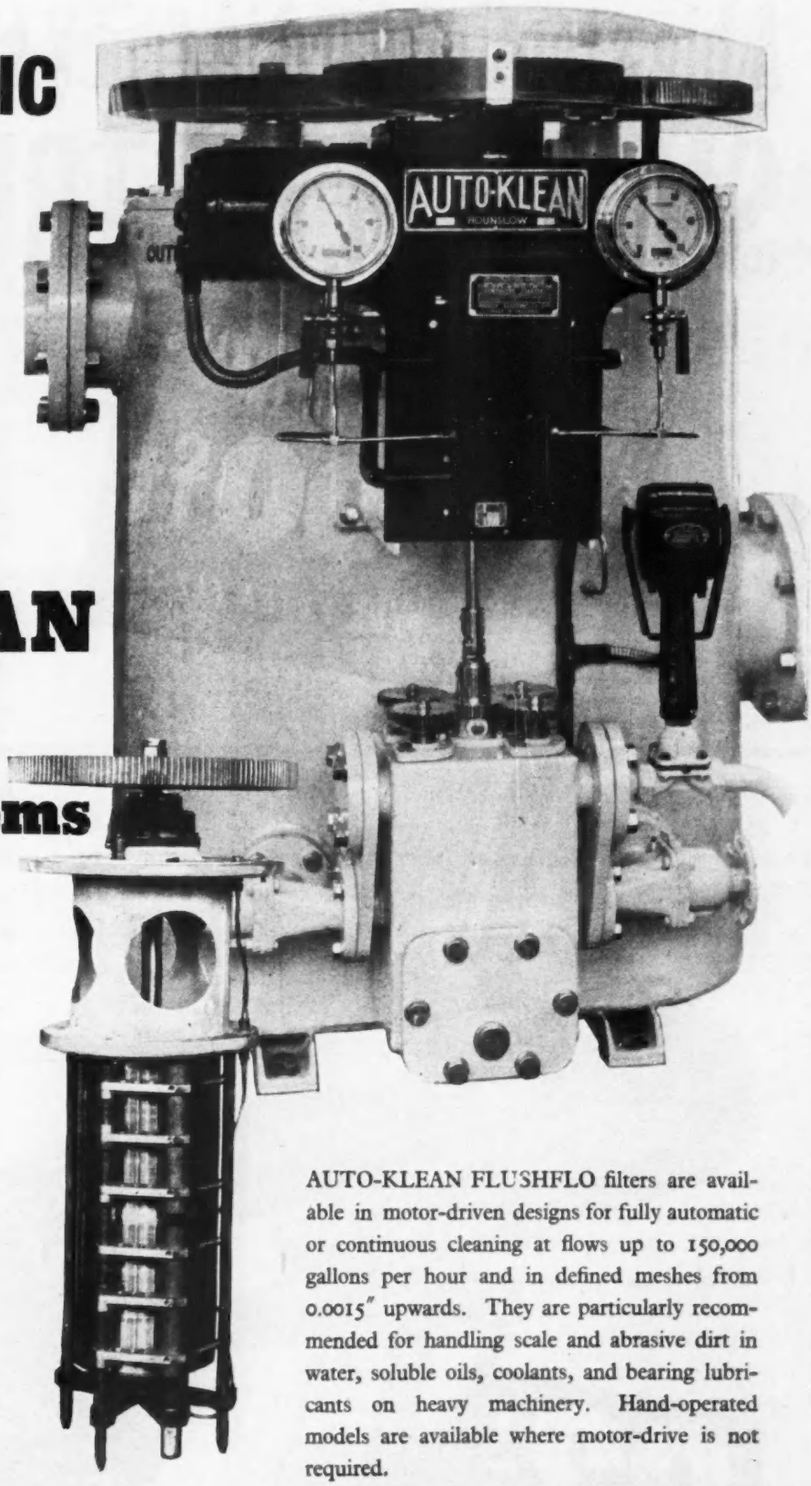

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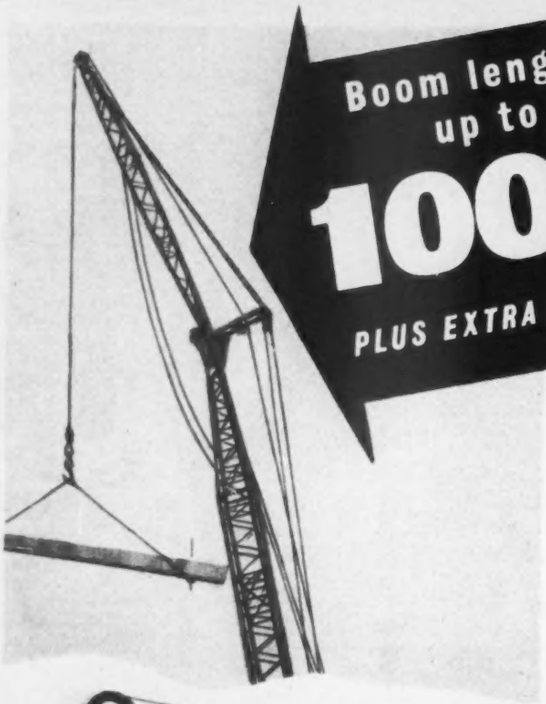

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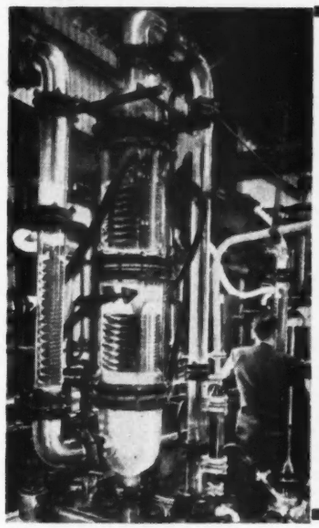
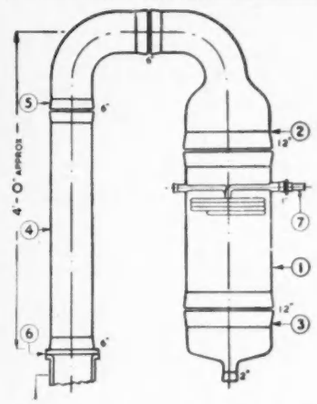


Glass Equipment used for Toxaphene production
(Photo by courtesy of Cocker Chemical Co. Ltd.)



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3	12" to 2" Pipe Reducer	PR.12/2	1
4	6" Pipe Section, 37" long	PS.6/36	1
5	6", 90° Bend	PB.90/6	1
6	6" Glass Spacer, ¾" thick	SS.6/¾	1
7	1" Hose Connector (Metal) complete	MHC.1	3

PARTS LIST for assembly of Unit RD57/D6 with Q.V.F. standard glass components

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	OAC/H
6000	$6\frac{1}{8}$	$14\frac{3}{8}$	$11\frac{3}{4}$	$22\frac{5}{8}$	OAD/H
12000	$7\frac{1}{4}$	17	14	$25\frac{13}{16}$	OBE/H
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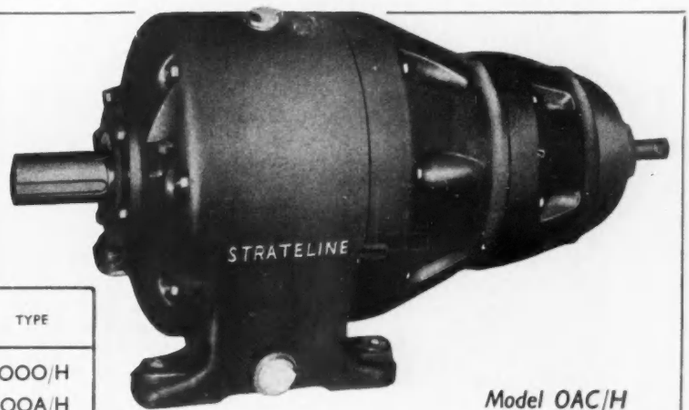

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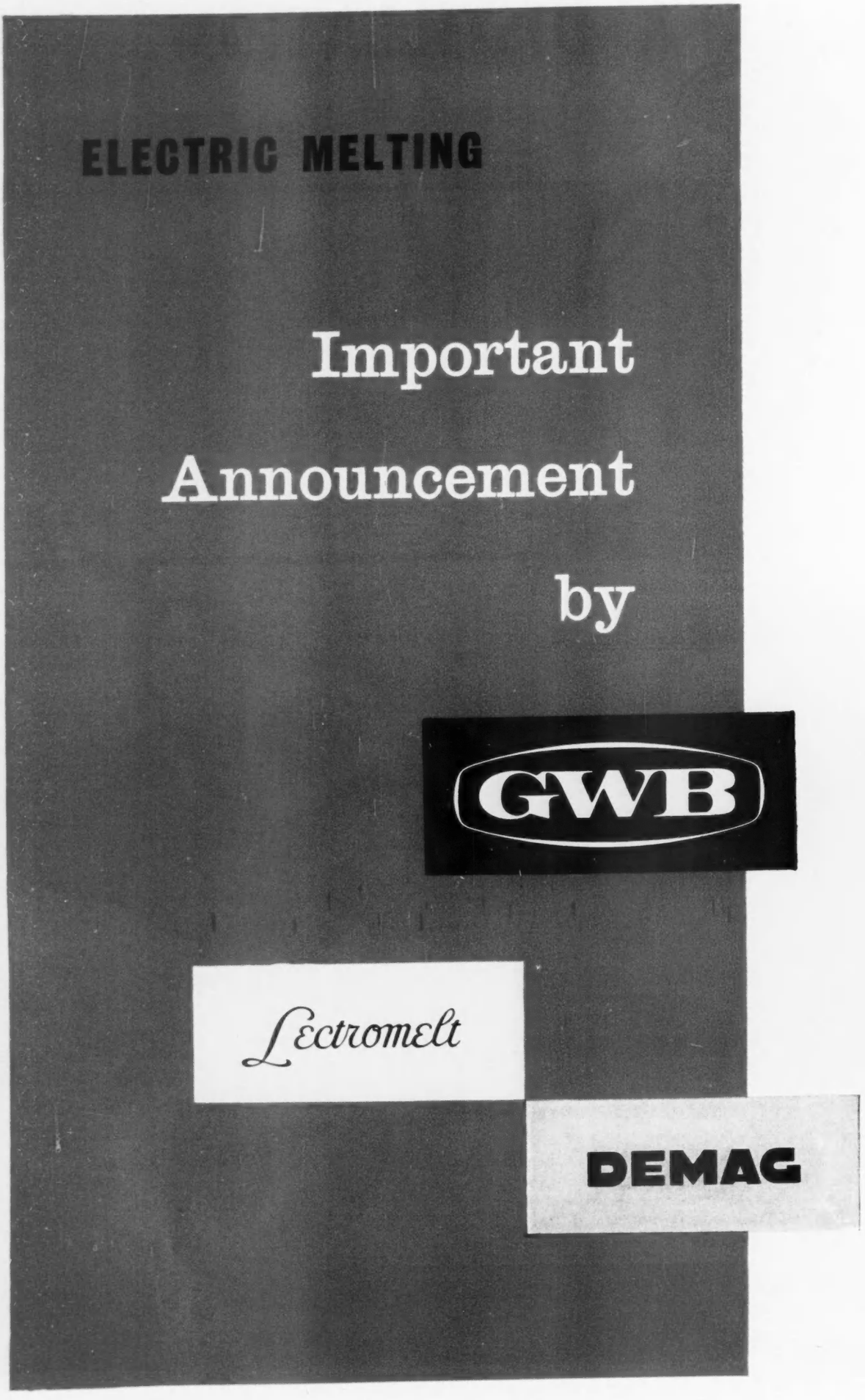
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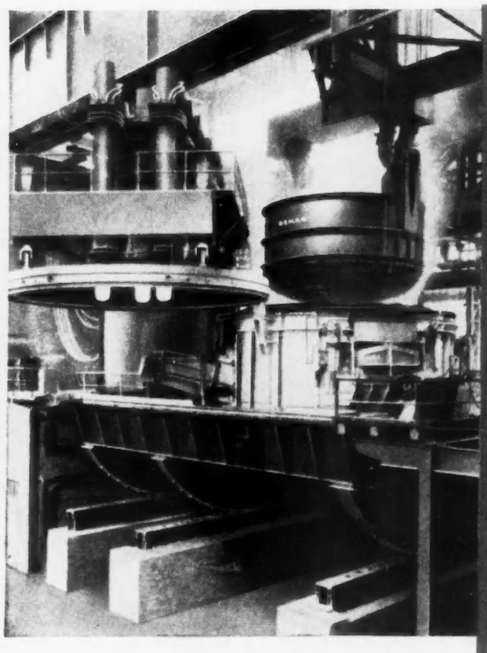
The names of DEMAG and LECTROMELT are synonymous the world over with all that is best in electric melting equipment. G.W.B. have now concluded Agreements for co-operative manufacture and sale, in Great Britain and many of the Commonwealth countries, of the whole range of melting plant designed by Demag-Elektrometallurgie G.m.b.H., Duisburg, Germany, and by The Lectromelt Furnace Division, McGraw-Edison Company of Pittsburgh, U.S.A. Demag and Lectromelt between them can justly claim to have had more experience of electric steel melting furnaces than any other company or association of companies in the world. Total installed capacity of Demag and Lectromelt Arc Melting Furnaces represents 6,750,000 kVA, corresponding to 2,800 installations. The unrivalled experience of these two companies enables G.W.B. to offer now, Arc Furnaces up to 200 tons capacity with alternative electrode control systems—static or rotating magnetic amplifier—hydraulic, with or without rotating shell. Completing the range of melting furnaces G.W.B. also offer the equipment detailed below.

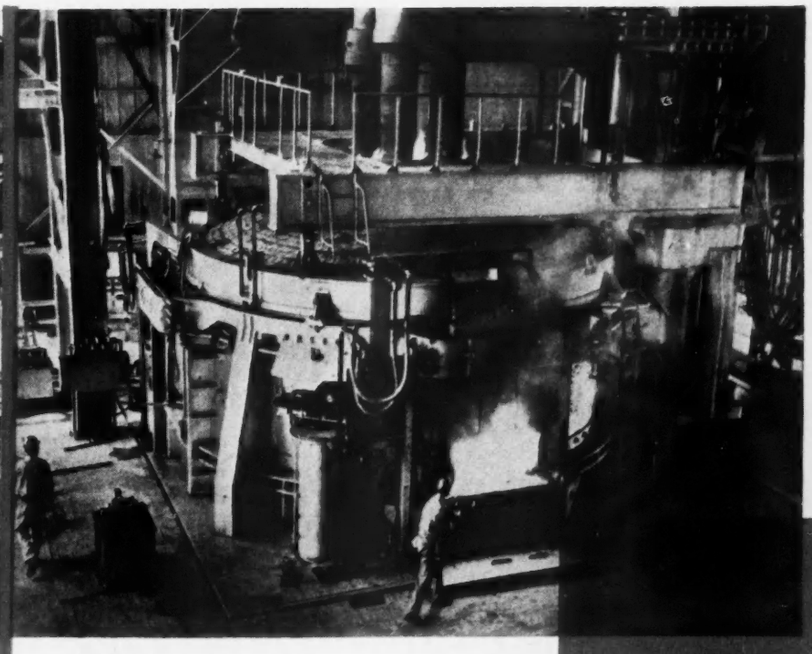
*DEMAG Submerged Arc Furnaces for the reduction of ores and production of ferro-alloys and calcium carbide. Connected loads exceed 850,000 kVA.

*DEMAG Channel Type Mains Frequency Induction Furnaces for melting light metals, copper and copper alloys, zinc and irons.

*DEMAG Crucible Type Induction Furnaces for mains frequency or motor alternator operation—for steels, irons and non-ferrous metals.



Demag 36,000 kVA Arc Furnace with 24 ft. diameter shell for Krupp-Rheinhausen.



Lectromelt 36,000 kVA Arc Furnace with 24 ft. diameter shell.

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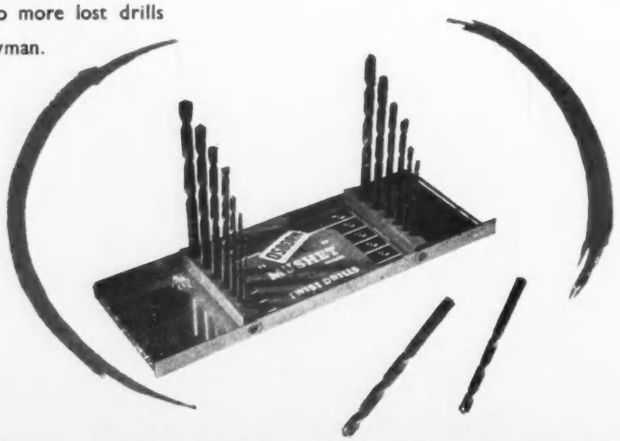

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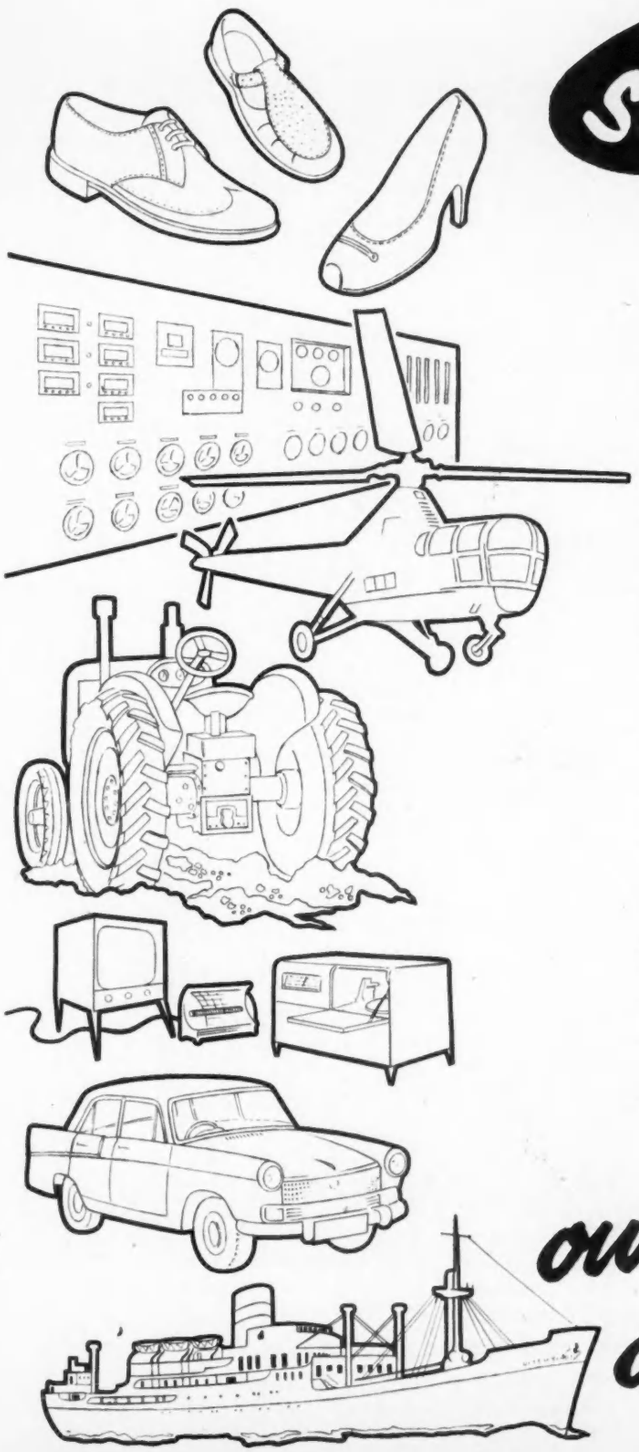

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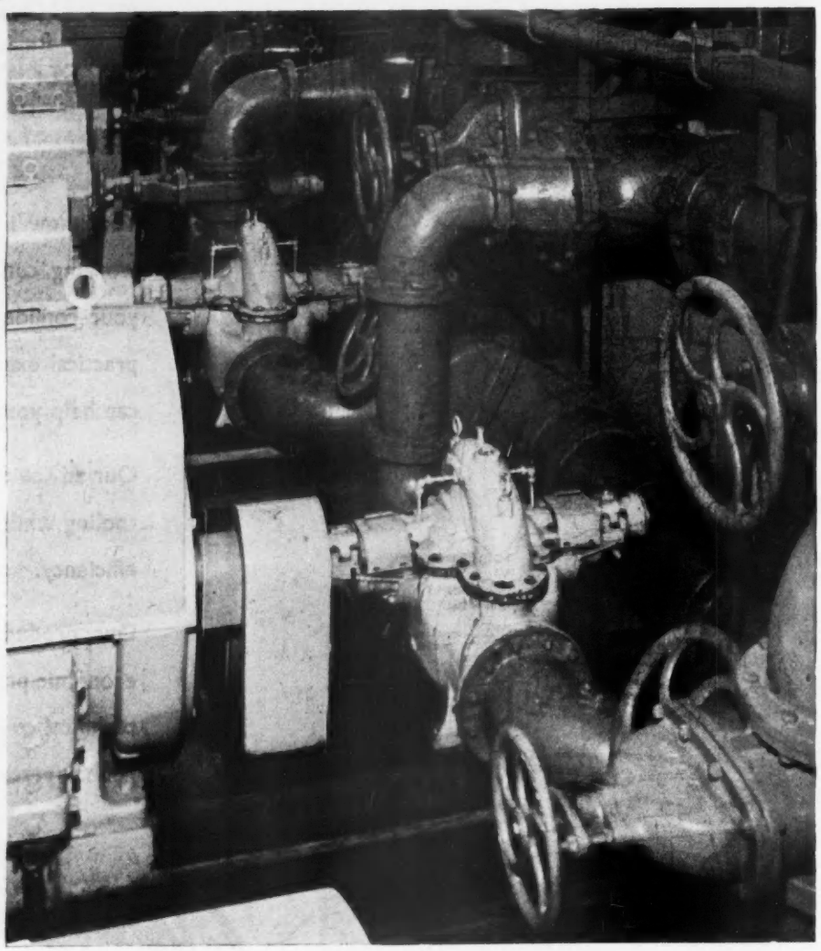
Gwynnes

Split-casing pumps



Gwynnes double entry Split-casing pumps are made up to the largest sizes for both Horizontal and Vertical Spindle arrangements.

The photograph shows Gwynnes 10″ and 12″ pumps supplied to the order of the Woodhall-Duckham Construction Company for the Avenue Carbonisation Plant, Chesterfield, of the National Coal Board.

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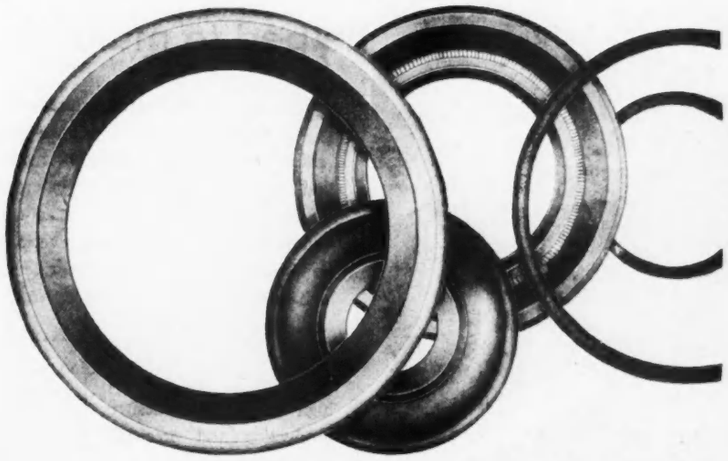

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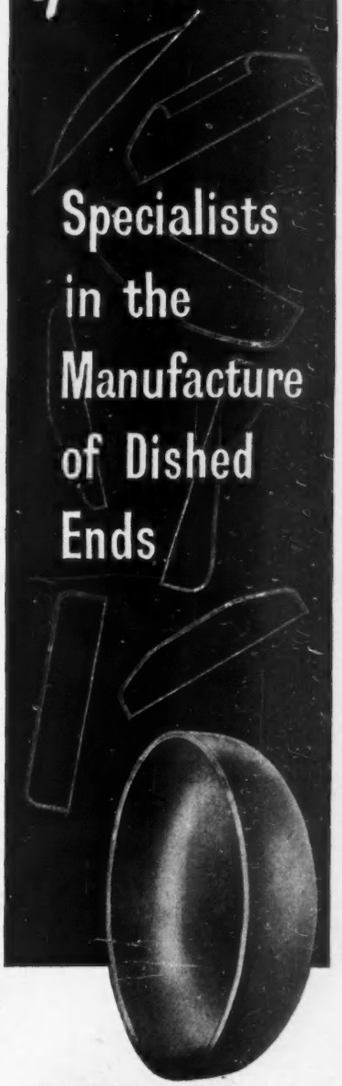

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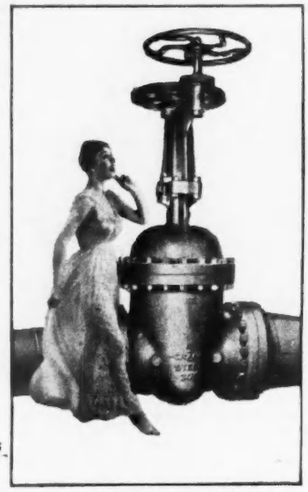

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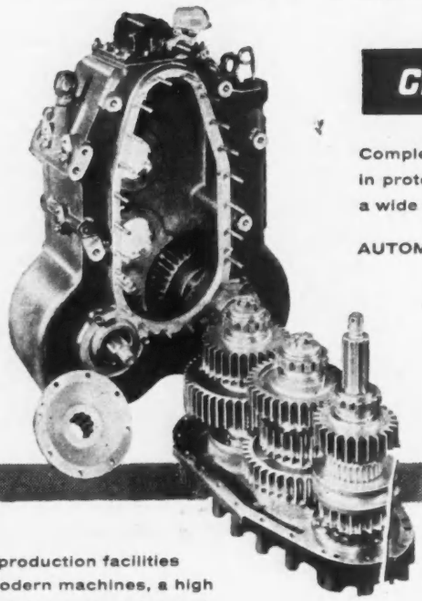

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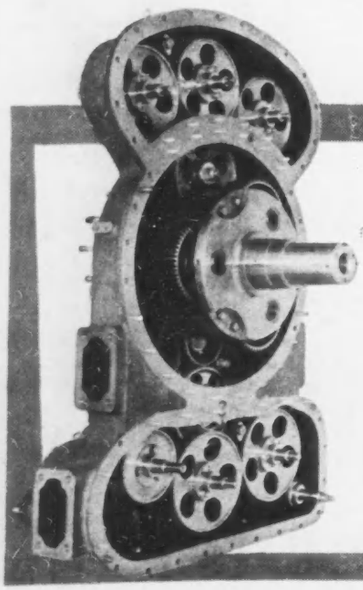

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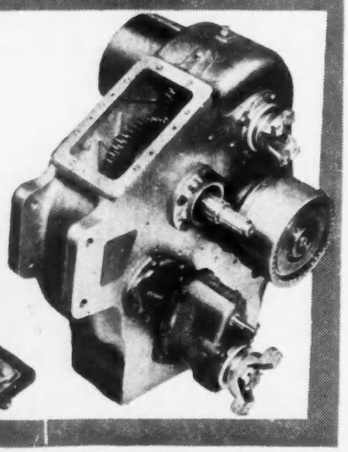

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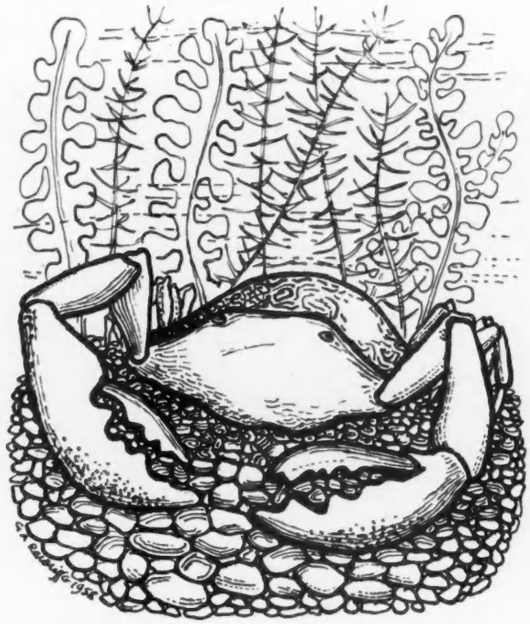

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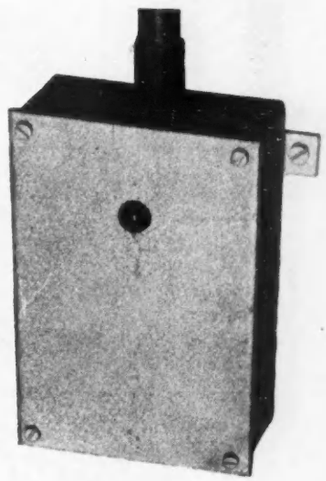

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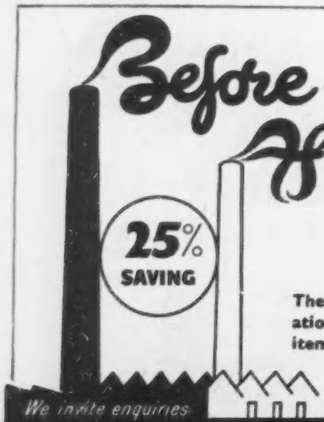

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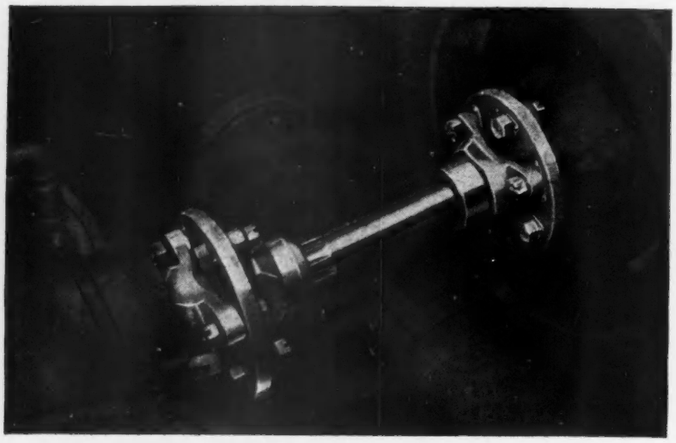

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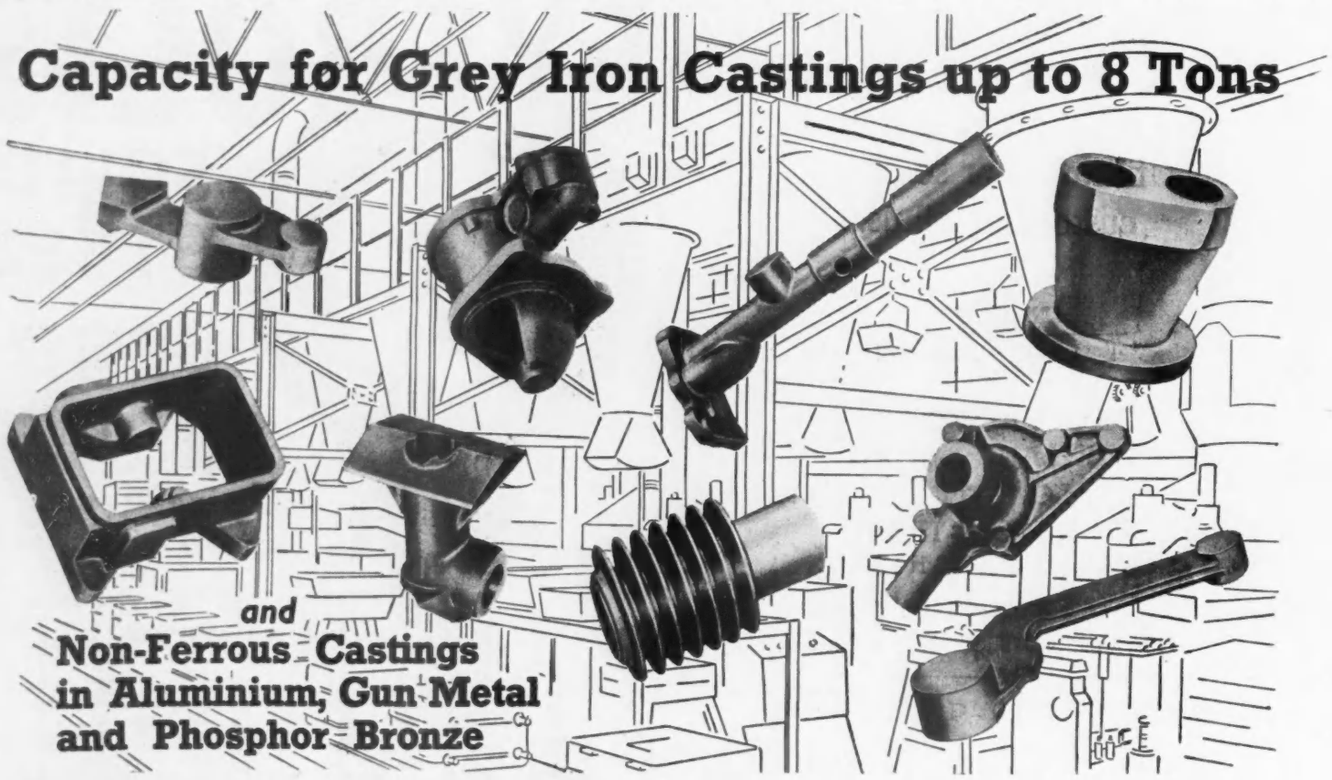

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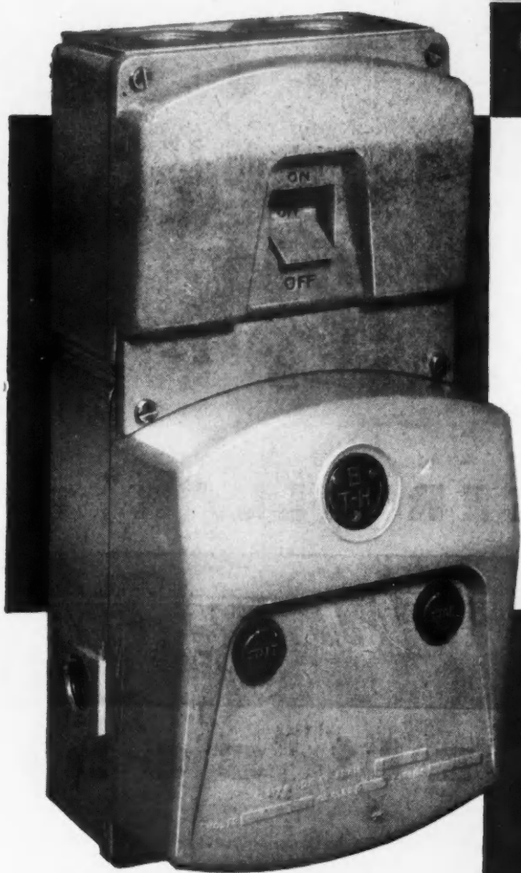

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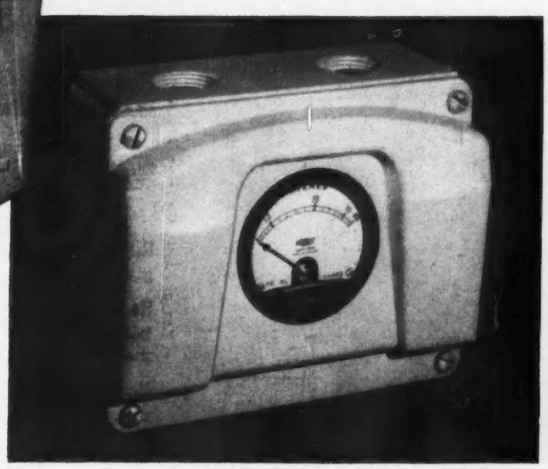

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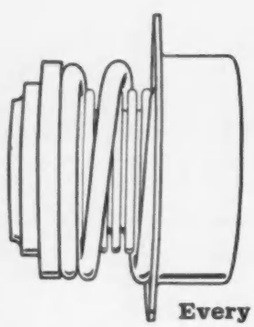

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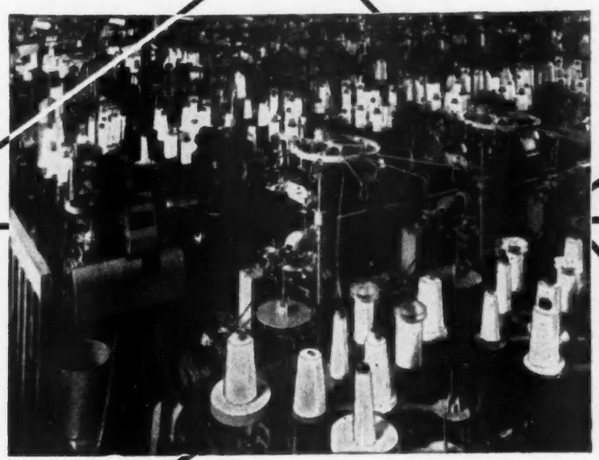

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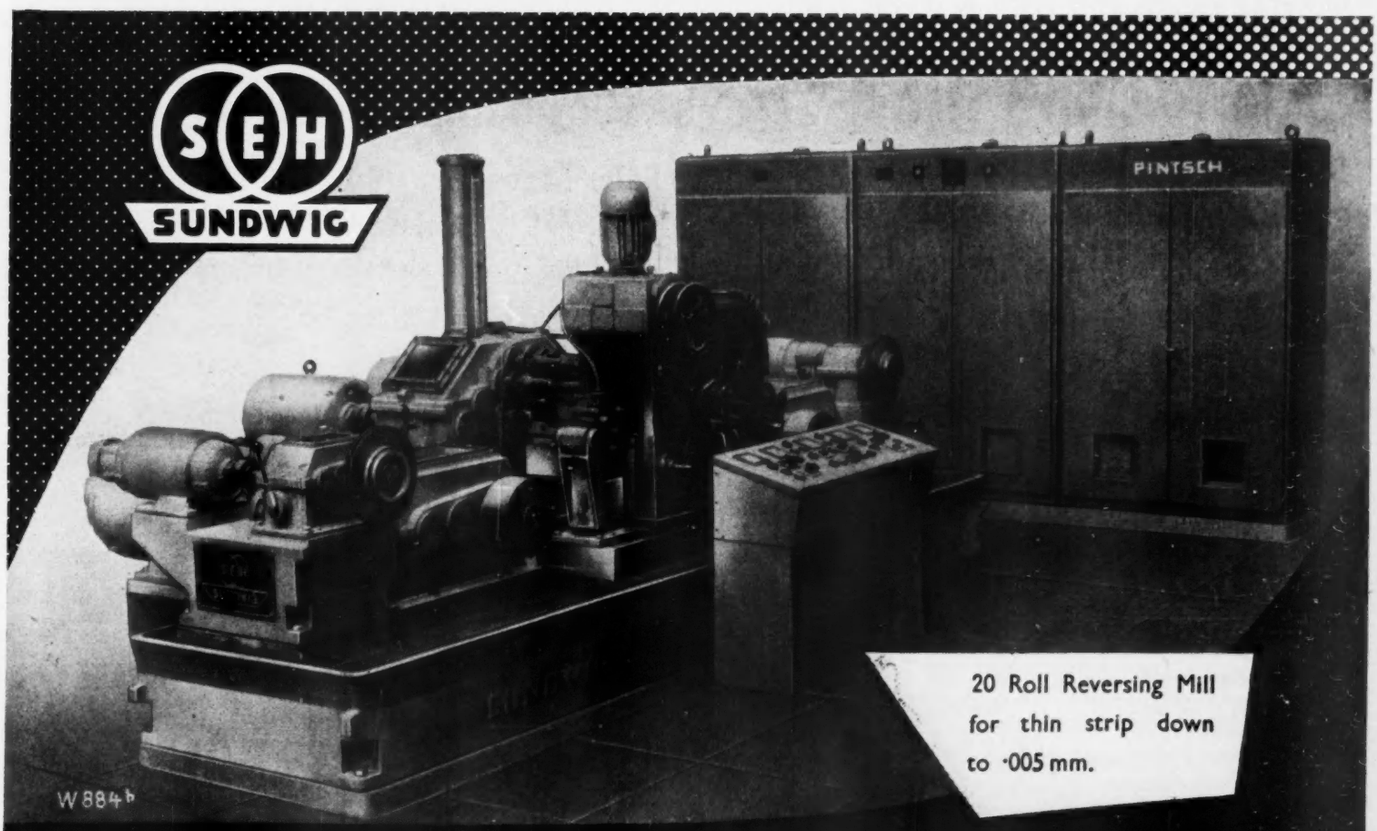

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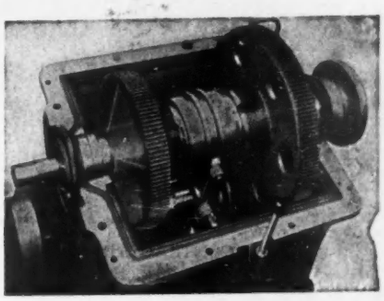

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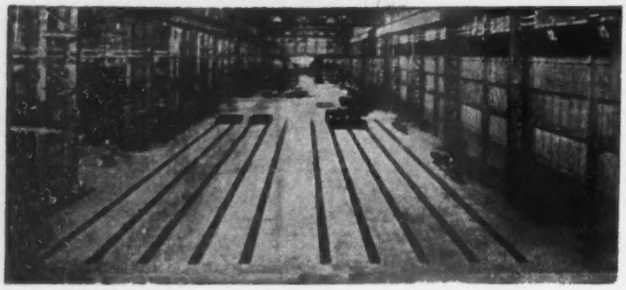

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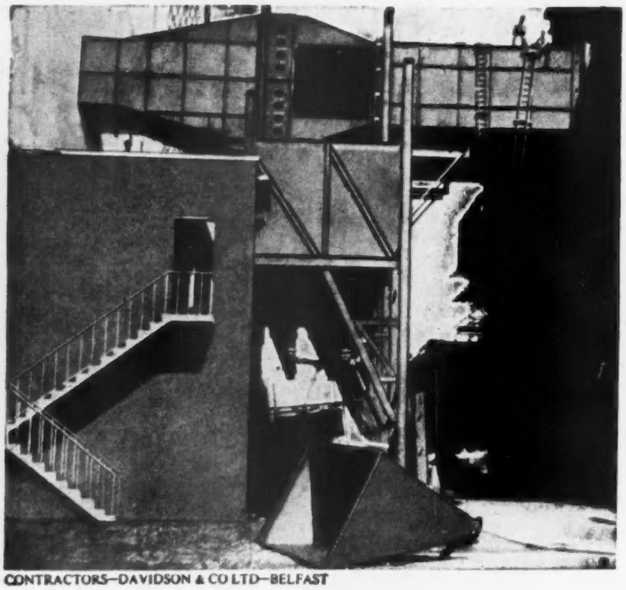

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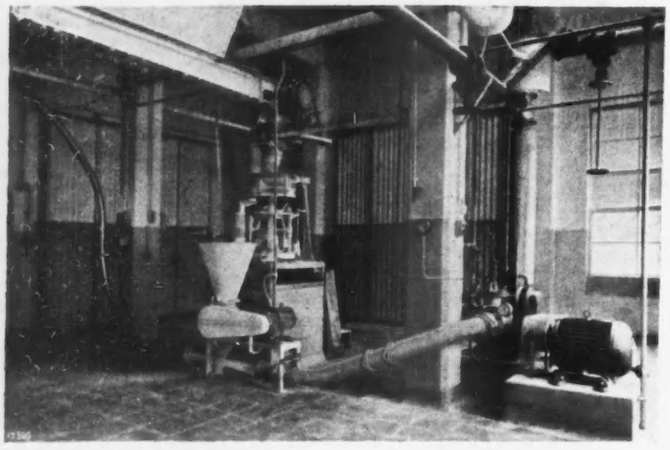

Part of a Sturtevant Pneumatic Conveying System handling a dry powder.
Photo by courtesy of Torridge Vale Dairies (Devon) Ltd., Torrington.

MATERIALS ARE

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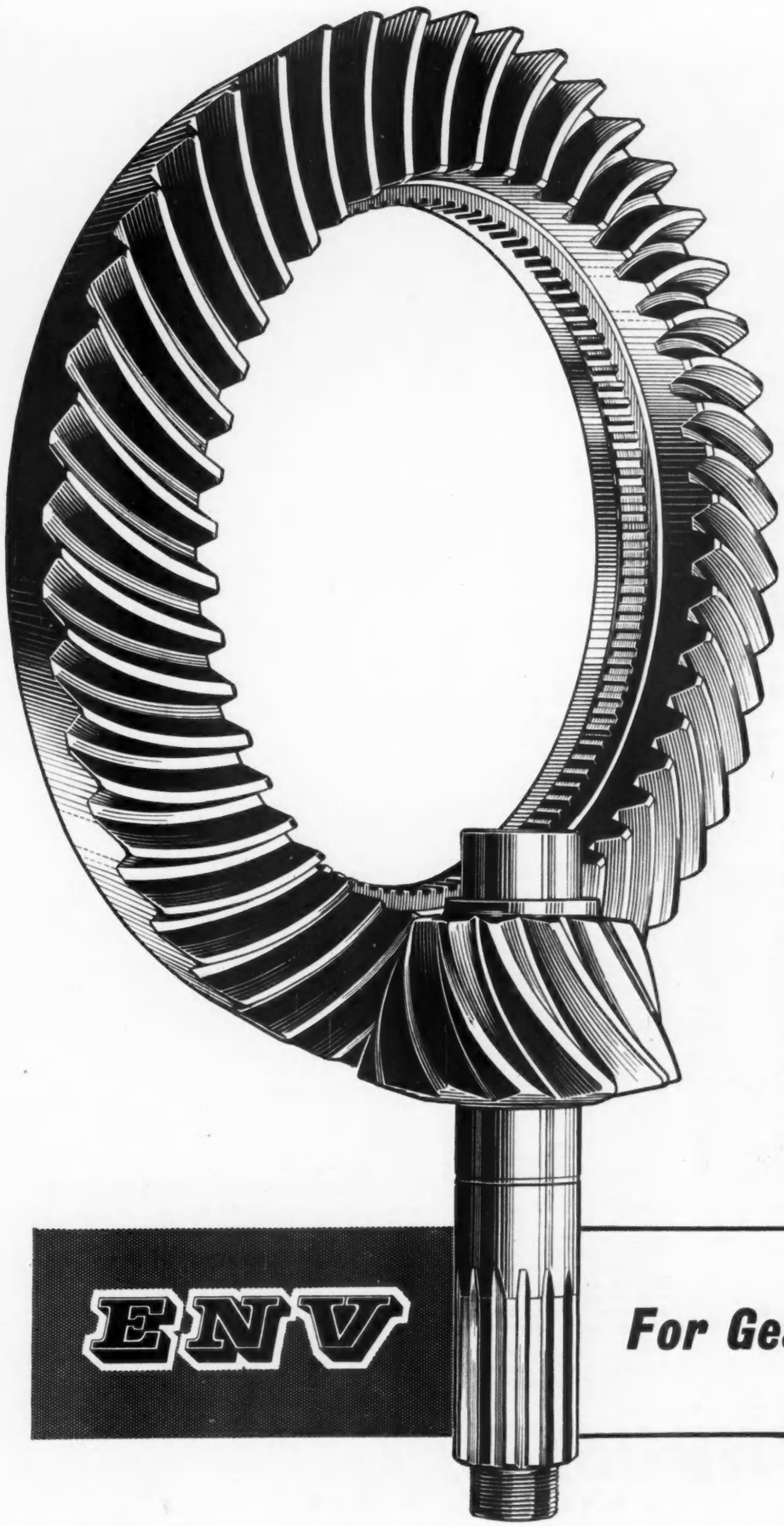

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constant tension supports

FOR LOADS UP TO 8 TONS
PIPE MOVEMENTS UP TO 18″

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British Patent Nos. 474008 720074 720075 697987 657318
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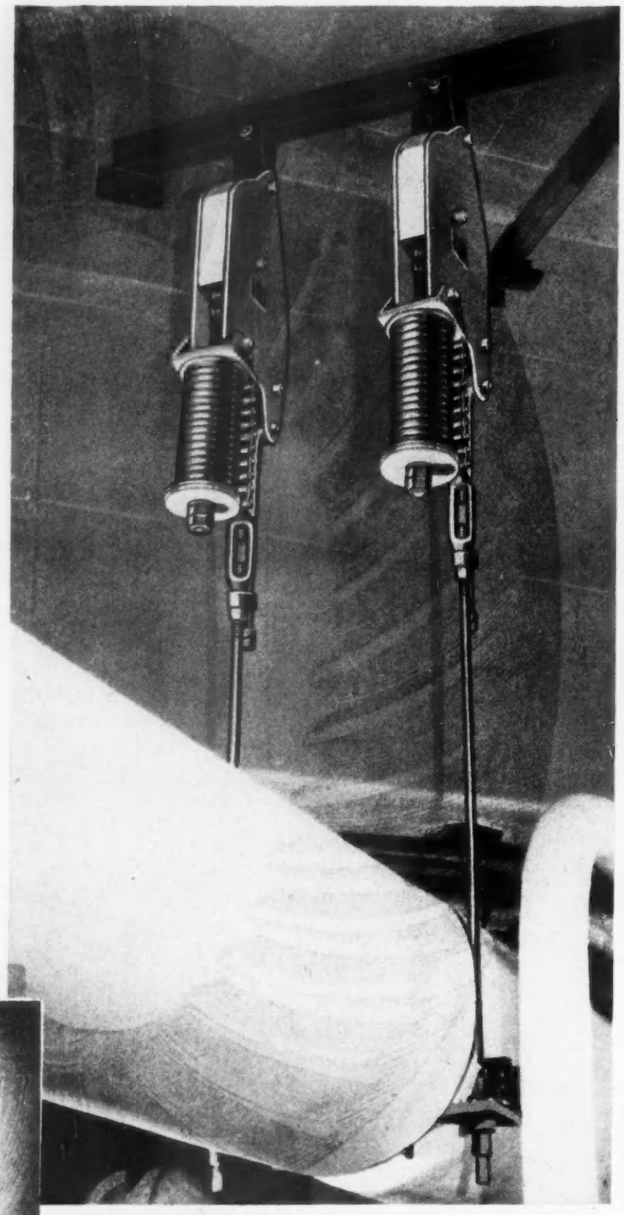
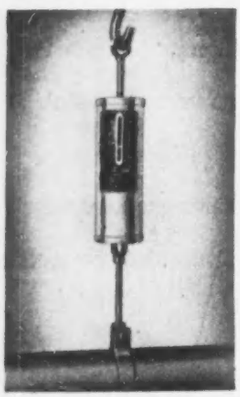
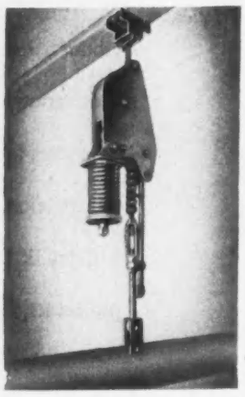


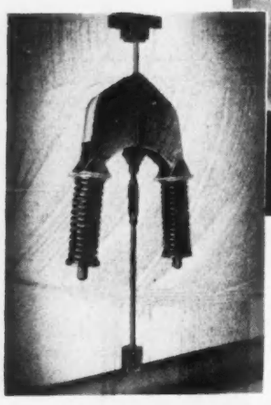
Ferrybridge " B " Power Station, Central Electricity Generating Board. Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds, Ltd.



Leflfried Red Top Pipe Supports for loads from 100 to 5,000 lbs. and total travel of 3″.

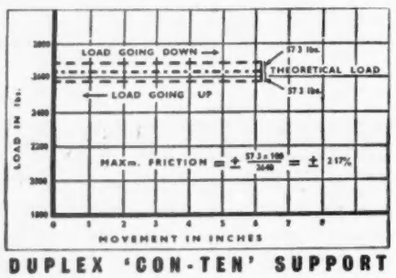


Conventional type " Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12″.



Duplex " Con-Ten " Supports for loads of up to 8 tons with a total vertical movement up to 12″. This type is acknowledged as one which produces minimum friction and kinematic variation. It has been specially designed for any applications where exceptional accuracy is demanded.

From graph it can be seen that the maximum friction is equivalent to 2.17% of the applied load.


LOAD GOING DOWN →
57.3 lbs.
THEORETICAL LOAD
← LOAD GOING UP
57.3 lbs.
MAXm. FRICTION = ± 57.3 x 100 / 3640 = ± 2.17%
LOAD IN lbs.
MOVEMENT IN INCHES

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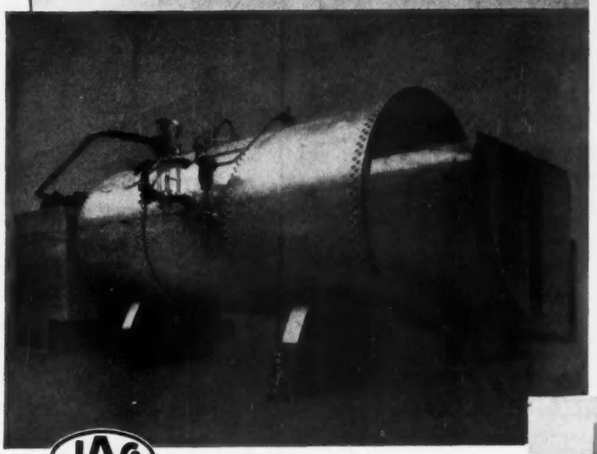
JOSEPH ADAMSON
Waste Heat Boilers



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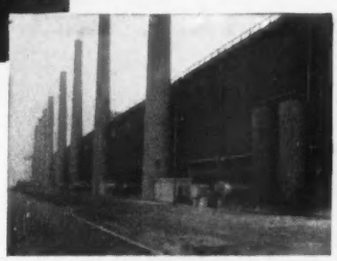

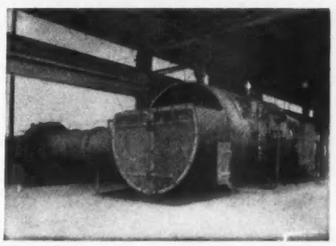

The Joseph Adamson Waste Heat Boiler is designed to make efficient use of the waste gases leaving open-hearth furnaces, reheating furnaces, soaking pits, gas retorts, etc.

The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

A feature of Joseph Adamson Waste Heat Boilers is that a special cleaning device can be provided in the outlet chamber to allow the tubes to be cleaned while the boiler is at work.

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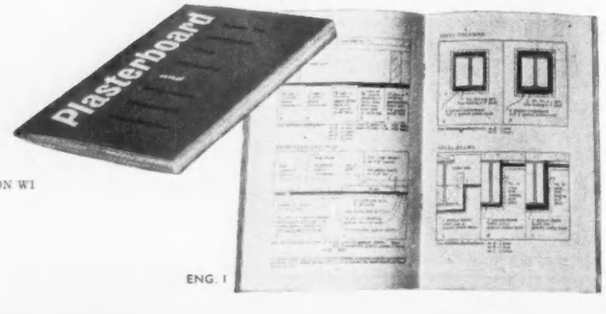
Since the introduction of The Thermal Insulation (Industrial Buildings) Act, however, it has become more than ever necessary that some form of reference should be constantly available to you. For this reason we have now added a supplement to our standard publication, to deal with the specific requirements arising from this Act. This supplement explains the clause dealing with Thermal Insulation Standards for Roofs. It also indicates how these standards can most adequately and cheaply be met by two straightforward forms of insulation, i.e. with Insulating Gypsum Plasterboard alone or with plain Gypsum Plasterboard in combination with a mineral or glass wool backing.

*Plain Gypsum Plasterboard and Insulating Gypsum Plasterboard are inexpensive sheet lining materials with a core of incombustible Gypsum. Both are rated Class 1 according to B.S.476, both surfaces of these materials constituting 'Surfaces of Very Low Flame Spread', without requiring additional treatment.



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ENG. 1

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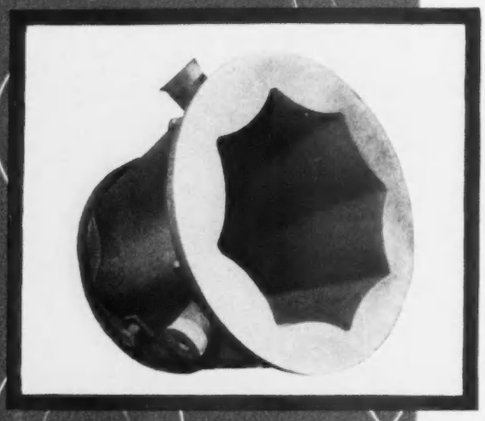

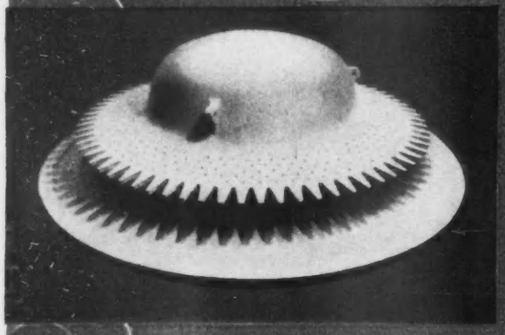

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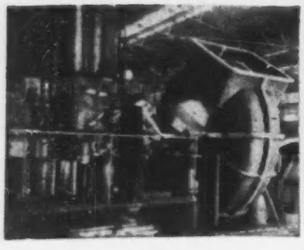

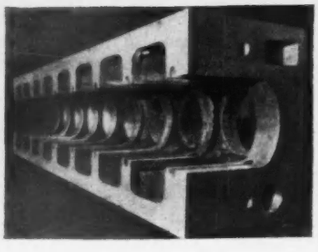

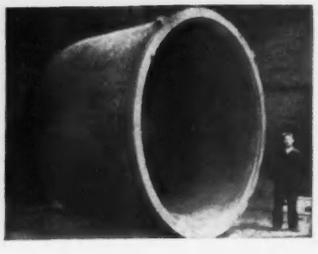

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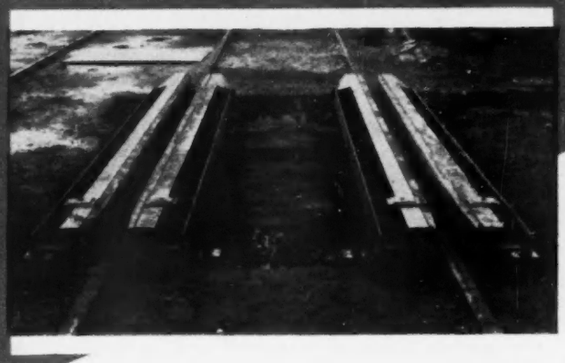

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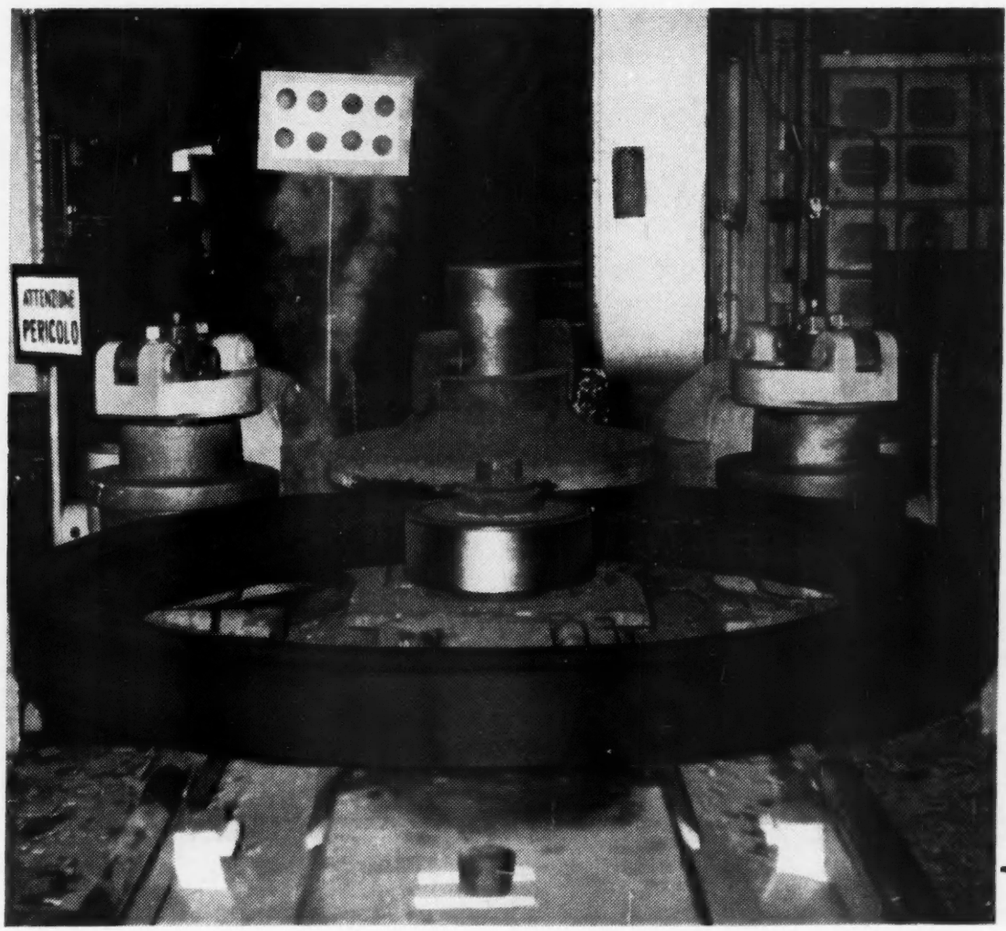

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This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, rivetting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

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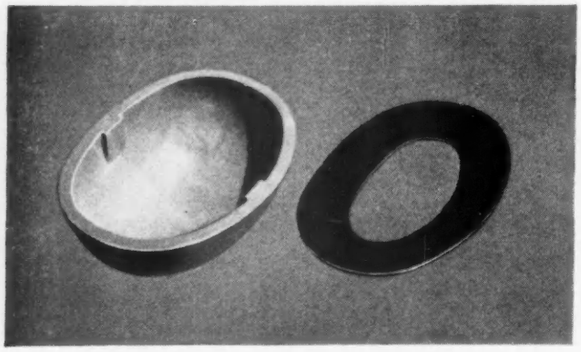

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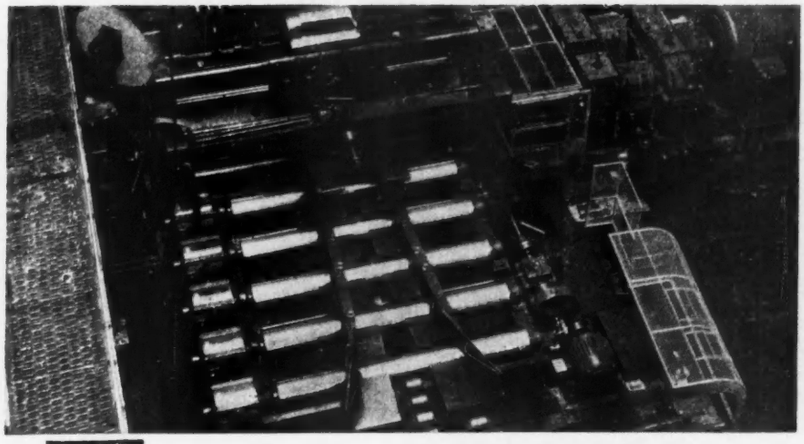

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Photograph by courtesy of The Northern Aluminium Co. Ltd.

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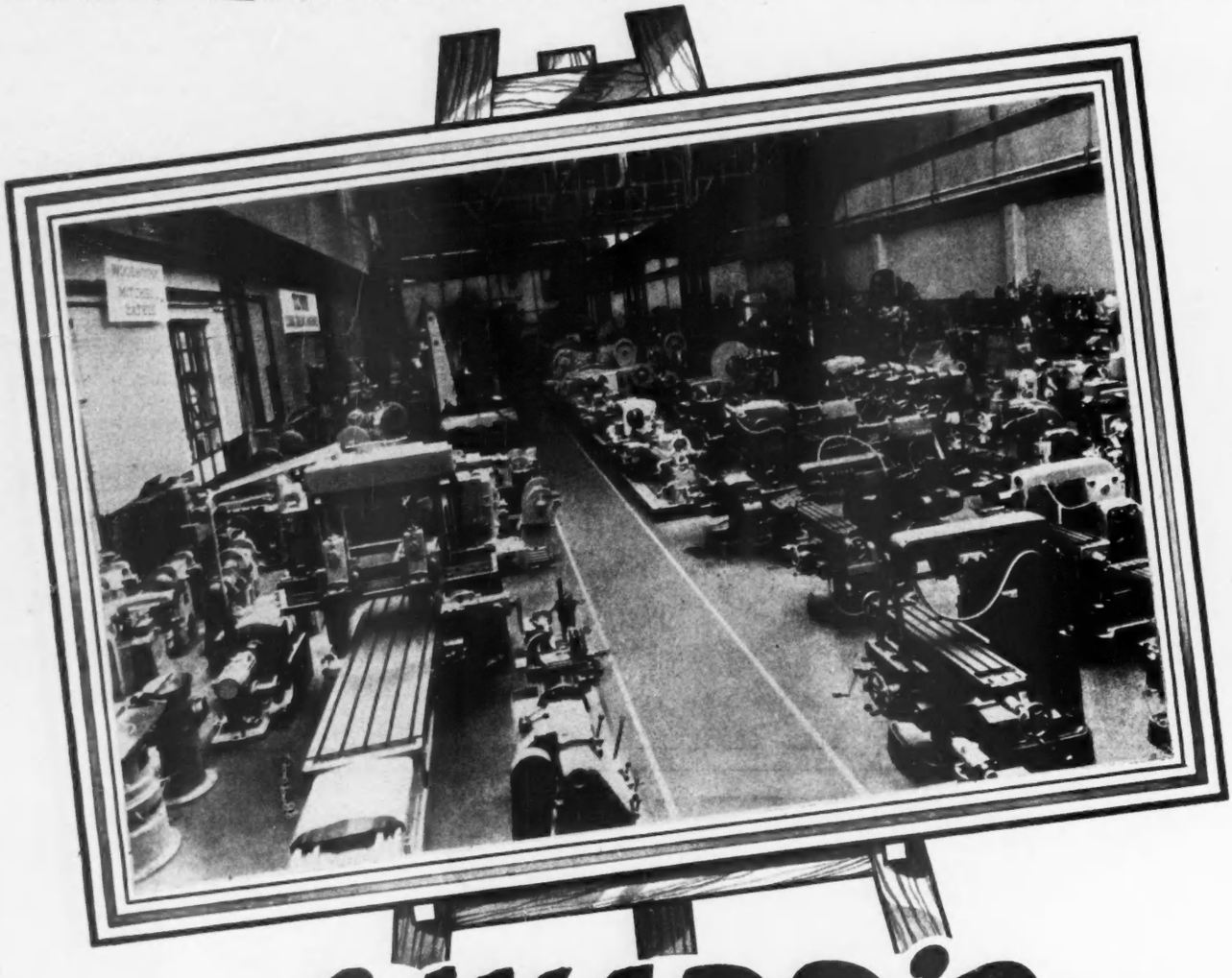

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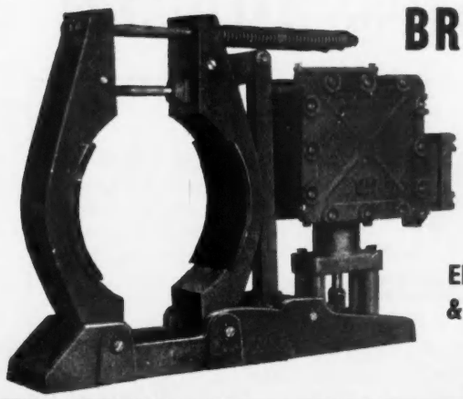

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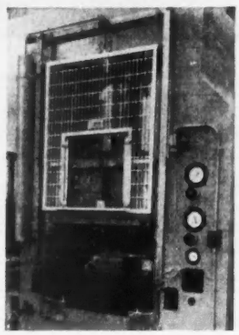

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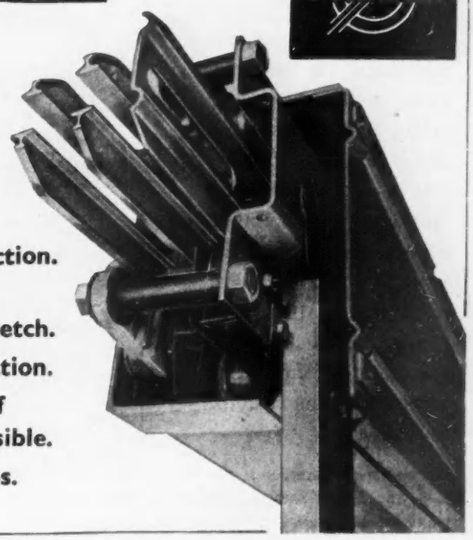

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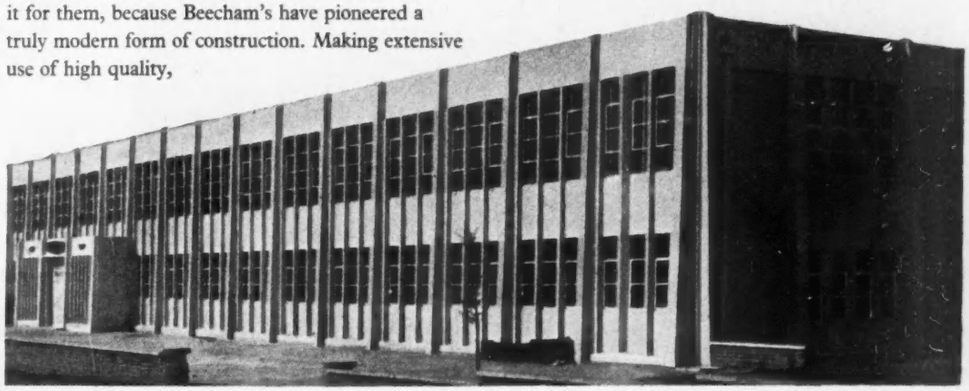

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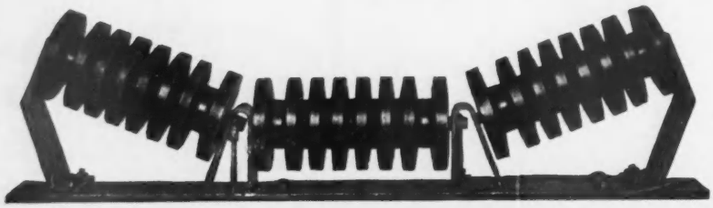

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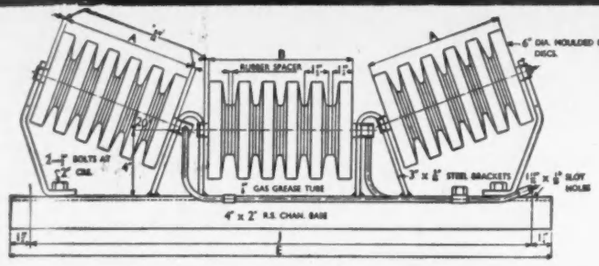
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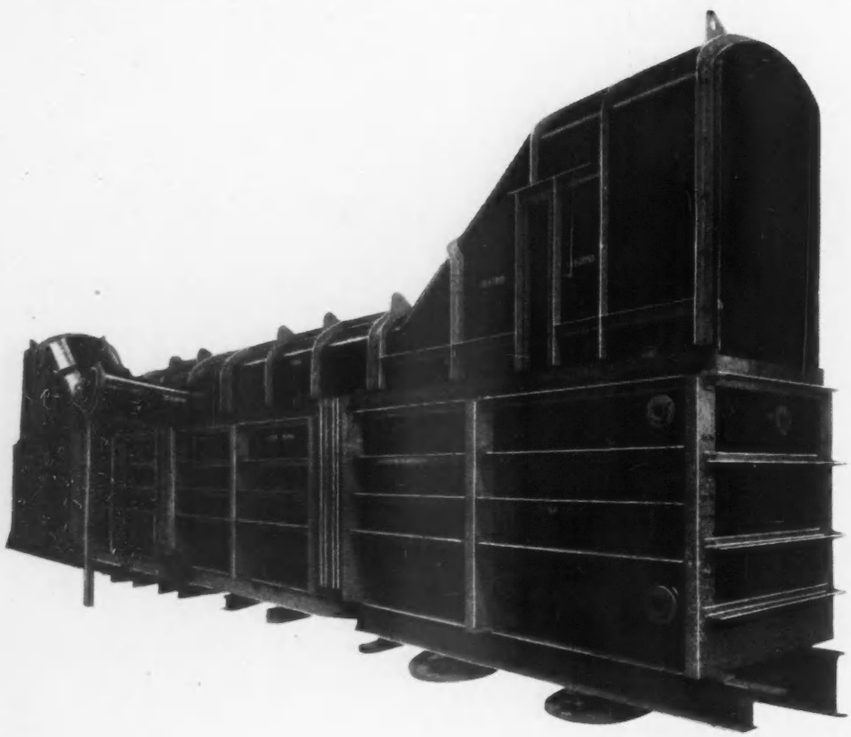

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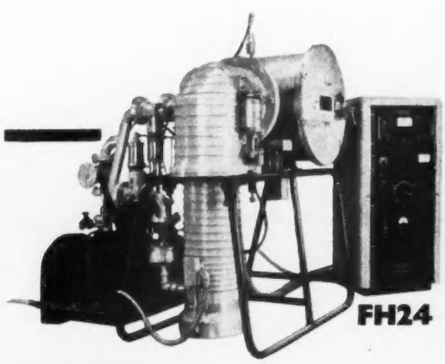

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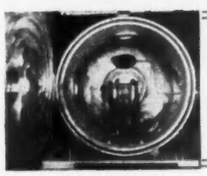

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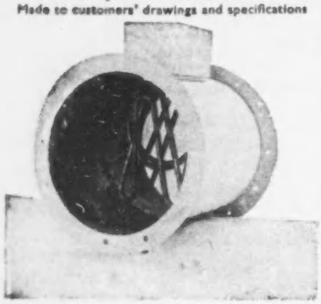

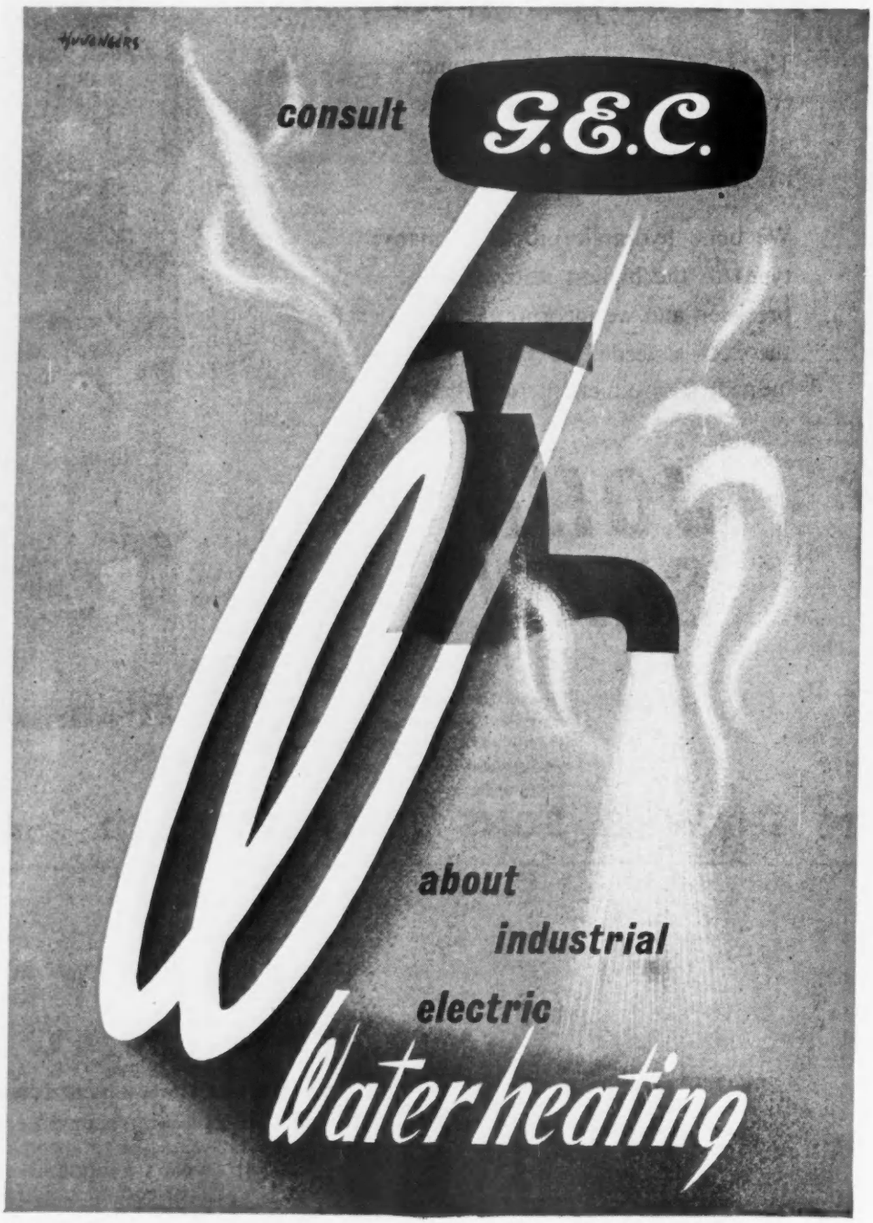

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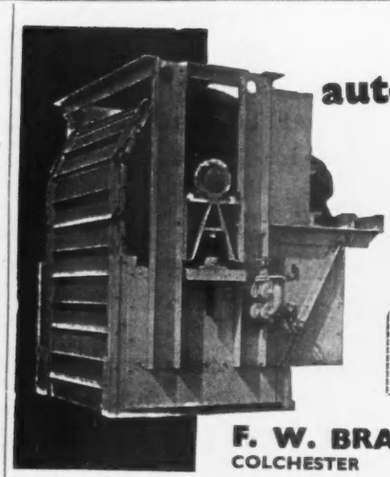

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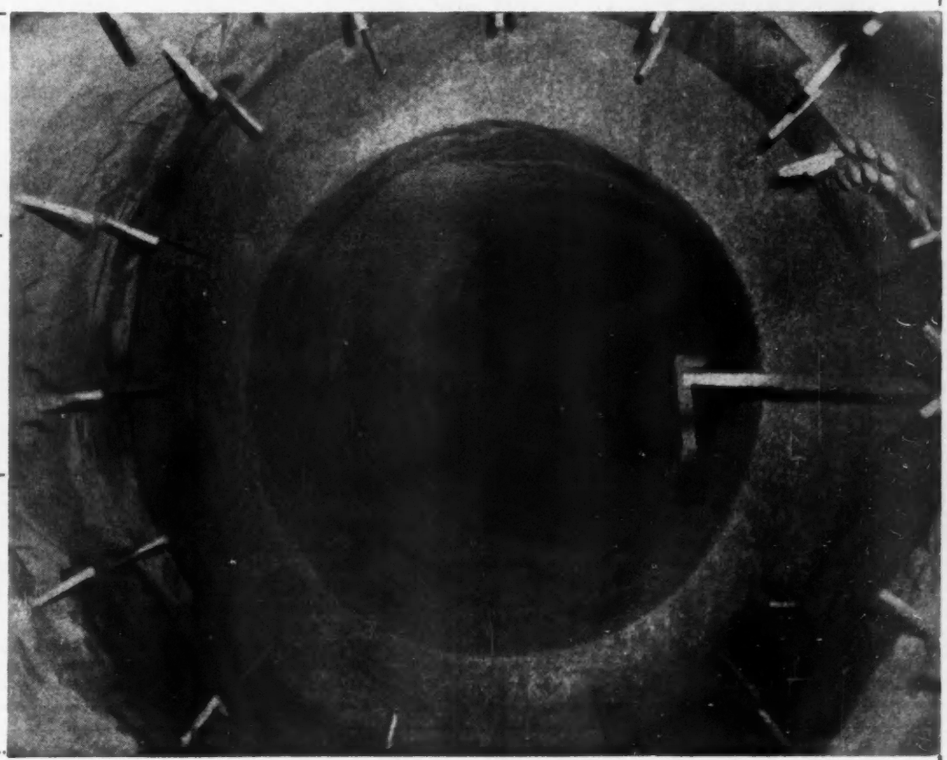

Number two is the answer. It is in fact the bustle-main of the Queen Victoria blast furnace at Appleby-Frodingham in course of being lined with Tri-Mor 'Guncrete'. The main is 5 ft. in diameter and the 'Guncrete' lining 9" thick. This is a far quicker and cheaper form of lining for a hot-gas main than brickwork. After twelve months continuous service this lining is still in perfect condition. Brick-lined mains usually require considerable repair after this period.

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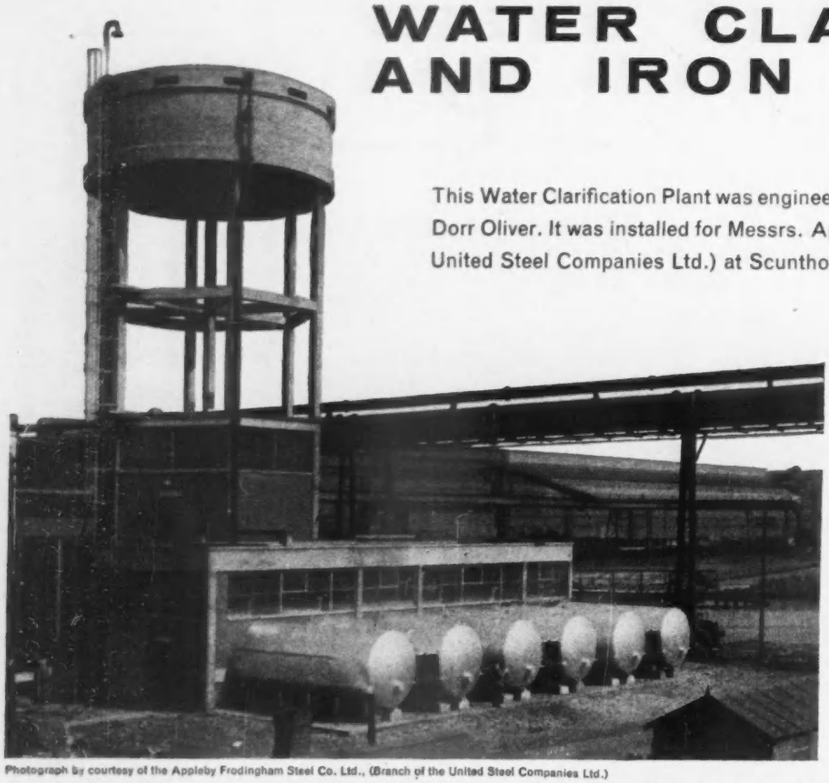

Photograph by courtesy of the Appleby Frodingham Steel Co. Ltd., (Branch of the United Steel Companies Ltd.)

This Water Clarification Plant was engineered by Lodge-Cottrell in collaboration with Messrs. Dorr Oliver. It was installed for Messrs. Appleby-Frodingham Steel Company (Branch of the United Steel Companies Ltd.) at Scunthorpe, and enables them to re-cycle the rolling-mill water. A large part of the total flow is cleaned through sand filters to leave approximately 1 part per million of solids. Secondary filtration of the thick slurry, taken off as underflow from the Clarifier, is also provided.

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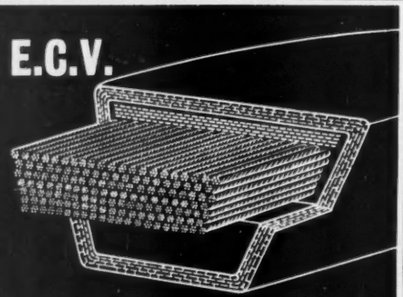

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THE ENGINEER

No. 5405 AUGUST 28, 1959 VOL. 208

THE RADCLIFFE REPORT

None of our readers, fortunately, will expect from us an Olympian pronouncement about the value of the report of the Radcliffe Committee on the Working of the Monetary System. For we are engineers not financiers, and our interest in economics is similar to that of anyone else who has to live and work within our economic system. We are, in fact, less interested in the working of the monetary system than in the effects upon engineers of the operations of those who think they know how to work it. The kind of community in which engineers would like to live, we suppose, would be one that best benefited from their activities. It would, therefore, be one in which standards of living were rapidly rising and the demand for capital goods was growing year by year. In short, engineers would prefer to live in a rapidly expanding economy ; but not in an inflationary one ! For amongst the vices of an inflationary economy there is one peculiarly odious to engineers. It is that when demand tends to outrun supply the shoddy can be sold almost as easily as the good. Thus engineers will have looked—like most other people—to the Radcliffe Committee to suggest a solution to a problem that has apparently baffled economists the world over, how to prevent inflation in an expansive economy. The Report of the Committee is very long. There are 337 pages exclusive of tables of contents, a number of appendices and some tabular matter. It has, however, the virtue of being written with such commendable clarity that any intelligent layman can understand it. There is a refreshing absence of economic jargon. So far, so good ! But the reader will look in vain for any economic nostrums. For the Committee makes no recommendations ; it merely reaches some conclusions.

We think that so far as they go the Committee's conclusions are sound ; and we think the politicians who rule over us should, though they probably will not, take notice of them. For example, " those responsible should avoid partisanship in advocating the merits of any one form of control at the expense of another. What is needed is not doctrinal preference but a constant and profound diagnosis of the state of the economy which is to serve as patient and a clear perception of the likely effects, indirect as well as direct, of any particular measures." Or, again, " Monetary measures are aimed at the level of demand, but by their nature they are incapable by themselves of having an effect sufficiently prompt and far-reaching for their purpose, unless applied with a vigour that itself creates a major emergency. They are not so much a policy in themselves as a part of one general economic policy which includes among its instruments fiscal and monetary measures and direct physical controls. There is no prescription which determines the proportion in which at any one period these measures should be combined." But we doubt whether such words will carry conviction to those who think otherwise, whether they favour monetary measures or more direct " controls," until more incontrovertible facts are available with which to convince them. The Committee has, therefore, performed another service by pointing out that not only are the statistics required to form a proper assessment not all available to the authorities, but that even fewer are published. The Committee comments, " If monetary policy is not to be authoritarian, and there is to be an informed opinion exercising an independent critical judgement over the measures adopted, the authorities must seek to avoid any unnecessary disparity between the information at their disposal and the information released for publication." It is no doubt true that there will always be diverse views about the economic policies any country should pursue, if only because human beings have such varied aspirations. But, at least, were sufficient information available, it should be possible to argue the question, " Where shall we go from here ? " rather than argue, as now, about the virtues and the probable outcome of any given policy. We commend the Report to those of our readers with an appetite for learning something about the workings of Britain's economic system. The fare is solid. But it is surprisingly digestible !

ANCIENT AND MODERN

The construction of that part of Route 11 which was opened on July 7 for traffic between Aldersgate Street and Moorgate provides the citizens of London with examples of things ancient and modern which must surely be unique in the history of road building. The new thoroughfare makes a diagonal crossing of the site and remains of the Town Wall built by the Romans at the end of the second century A.D. It also crosses the site and remains of the Roman fort which, believed to have been built between A.D. 70 and 80, occupied the north-west corner of Roman London. This magnificent road, constructed with dual carriageways each 29ft wide and having ample side pathways and a central dividing strip, traverses a part of the City which is thickly charged with historic interest. Its northern pavement covers part of the site of that fourteenth century Hospital of St. Mary-the-Virgin which was the earliest recorded effort (in London) aimed at ameliorating the sad lot of the blind. Adjacent to the new thoroughfare is an impressive length of the mediæval wall still crowned by its Tudor battlements. The ancient Guildhall of London is close by, and round about stand the war-damaged remains and sites of immemorial churches and of the halls of City companies. Over this bomb-shattered area passes the new roadway and we may wonder what Vitruvius and his colleagues—who possessed considerable knowledge of the action of masonry under compression—might have thought of the

suspension of the road over a great car park with space for some 1250 cars. The Romans were, of course, particularly indebted to their cement and to that "pozzuolana"—containing an important ingredient of volcanic ash from the neighbourhood of Vesuvius—which would harden even under water. As practical men having great experience in the design of public works, they might express the opinion that only time could decide the merits of the design and materials embodied in the construction of Route 11. Moreover, they would be able to point to that section of concrete conduit which, dating from around A.D. 80, is to be seen in the Smithsonian Institution at Washington. We read that "when dug out some eighteen centuries later, it did not crumble or crack when drilled or chipped but behaved like stone." It was with such cement as was used in this conduit that the Romans built the dome of the Pantheon, the baths of Diocletian and Caracalla, the Pont du Gard and other famous structures which remain—in whole or in part—to this day.

Since it is possible that the Roman Wall of London was built during the reign of the Emperor Marcus Aurelius Antonius, we may wonder what reflections might have fallen from the illustrious author of the "Meditations" could he have known that after the passage of close upon eighteen centuries, part of the wall of London would, during the reign of Queen Elizabeth II, be preserved in the midst of so impressive a setting. Did he not write that: "The universe is change; our life is what our thoughts make it. . . . Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms." Those who survey that section of the Roman Wall which has been left undisturbed and accessible below the new thoroughfare and who then look around at the car park and above at the dual roadway, contemplate a deeply impressive example of that change of forms the importance of which is emphasised by Marcus Aurelius. They will also feel conscious of gratitude to the Streets Committee of the Corporation of London not only for preserving the historic relic but for the tribute they have thus paid to the memory of the Roman builders who set it up nearly eighteen centuries ago.

PRESERVATION OF TRANSPORT RELICS

Engineers, at work, have so nearly impossible a task in attempting to keep abreast of developments in science and technology that for many the study of past events must be relegated to leisure hours. For us, however, duty can often be combined with pleasure. A valuable opportunity was offered us last Sunday at Basildon by the second rally of the Historic Commercial Vehicle Club, to which there came a score of steam, electric, petrol and oil-engined vehicles built from 1913 onwards. Many of these were so lovingly and laboriously prepared as to excite deep sensuous pleasure in the beholder, but a series of driving tests ensured that the main aim of the club—the maintenance of vehicles in good condition—had not been subordinated to the lust to win cups in the Concours d'Elegance. Particularly deserving of praise are the enthusiasts comprising the Vintage Passenger Vehicle Society. For a p.s.v., perforce, has no intriguing working parts on view, it possesses vast areas of paint to be polished, cleaning the saloon alone is a fearsome task, and the sheer bulk of the machine renders garaging it a formidable proposition. Add to this the difficulty of access to the chassis and suspension, and it appears a tribute to the original constructors that the vehicles are a source of joy rather than of worry to the amateurs who own and run them to-day. Those manufacturers who take a pride in their past, but have no room to store a fleet of unproductive vehicles, might, we suggest, consider the possibilities of offering to the club members the ordinary facilities of a service department, such as inspection pits and degreasing plant.

Profit as well as pleasure was, however, to be had from a close study of the vehicles. How easy it seems to apply a push-on hand brake, and how much more readily one withdraws a dipstick appearing in the cab rather than under the bonnet! It is salutary to be reminded that the major castings were expected, at one time, to be of light alloy, and that exposed propeller shafts, let alone sliding joints, are anything but classical. The combination of a near-silent, overhead-camshaft oil engine with a clutch stop and a crash box may be a driver's delight rather than an operator's bread-winner, but epicyclic gearboxes, changing, forward or reverse, against the torque, have an obvious application to-day, when one sees 10-cwt vans powered by 1-litre passenger car engines and continually hears first and reverse being crunched home. And it may be only when one ponders the Gilford, with its air springs in series with the leaf springs, that one realises that to-day's solution, with such springs in parallel, reduces but does not dispel the "stiction" that allows small disturbances to pass right through the laminated spring.

More sombre thoughts must spring from the display, the day before, of a S.E.5a belonging to the Shuttleworth Trust and restored by the Royal Aircraft Establishment. This machine also has been brought to a standard in which it can be demonstrated in action, and after the Hispano had finally responded to the efforts of a Hucks starter—which itself would have incurred fearful penalties for un-Ford-like behaviour had it been entered at Basildon—two flights were made. The sight of this historic machine in flight over Farnborough carries one back, surprisingly few years on the calendar, to when air warfare was in its infancy—though evolving fast—and the intractable problems of procuring in adequate quantities weapons equal to an advancing state of the art were barely recognised. Beside the Royal Aircraft Factory relic there stood a Hawker "Hunter," preferred before the afterburning "Swift" for air combat and reminding one forcefully that the S.E.5a was less successful as a fighter than aircraft inferior in speed, in ceiling and, most emphatically, in handling qualities: the linear antecedent of the "Hunter," the Sopwith "Camel," had the vices of the rotary-engined aircraft to an extreme degree. It is easy to-day to recognise the handicaps of a mixture of guns of different designs, belt and drum feed, with one gun on a movable mounting above a far-from-rigid braced structure: the "Camel" already had the armament standard on fighters for many years after—its stable-mate, the "Dolphin," a conspicuous exception—a pair of synchronised guns. Neglect of the primary purpose of a war-plane was a surprising, but indisputable, feature of the designs of the institution devoted solely to equipping the Royal Flying Corps. From Farnborough came the B.E.2c, now remembered mainly as an example of early de Havilland design: this aeroplane, elementary as it now appears, was technically of great interest, being endowed with artificial stability, but the appreciation that preceded its adoption appeared to have ignored completely the "courses open to the enemy," and its vulnerability was so extreme that the casualties were, in the mind of a contemporary observer, almost the victims of a murderer. It is well to be reminded that to place financial or political considerations before or even beside military necessity may be to contemplate, if not commit, murder.

COST OF THE DETERRENT

June, 1959, provided milestones in the history of both the Royal Navy and the United States Navy. Three days before the Duke of Edinburgh laid the "keel" at Barrow of Britain's first nuclear-powered submarine, the first U.S. submarine designed to fire intermediate range ballistic rockets was launched at Groton, Connecticut. For the people of the United States, the "George Washington"—as this vessel has been named—is something more than a new departure in submarine construction. She, and the others of her class, will do much to help in eliminating the fear—ever present in American minds—that the United States power to retaliate might well be destroyed or greatly reduced by a sudden and unexpected attack. Costing over £36,000,000 to build, she will be capable of launching sixteen "Polaris" rockets, either when on the surface or submerged, and is being provided with two crews to enable her to remain almost continuously at sea in emergency.

Although the "Polaris" submarine will provide the safest and most effective deterrent yet devised, the last of six super-carriers of 60,000 tons, each costing over £70,000,000, is now nearing completion and all six are designed to operate heavy bombers with a range of 1000 miles. These carriers are to be supplemented by still larger and more costly carriers, powered with eight nuclear reactors, the first of which has been laid down. A third of the Strategic Air Command's bombers are in future to be maintained at fifteen minutes runway alert, with the aircraft parked close to the runways and their crews eating and sleeping nearby. Finally, sites, 100ft underground and lined with concrete, are being constructed, at great cost, for the three types of ballistic rockets of intercontinental range—the "Atlas," the "Titan," soon to reach the production stage, and "Minuteman."

It is not generally realised that the immense cost of the I.C.B.M. programme lies even more in the support equipment required than in the cost of the missiles themselves. Under the concrete launching site are great lengths of piping and tubes and pumps for liquid nitrogen, hydrogen and oxygen. Protection has to be provided for instruments of all kinds—sensors, recorders, gauges and computers. Generators for electrical power, automatic checking equipment, hoists and elevators have all to be placed under shelter. And the quantities of structural steel, sheet steel and concrete required are immense. The cost of one "Titan" is approximately £700,000, whereas a launching base for a squadron of nine of these missiles is estimated to cost over £16,000,000. The construction of several launching bases has already been commenced, present plans providing for twenty I.C.B.M. squadrons which, combined, would be capable of launching a salvo of 180 missiles. Meanwhile Congress, which seems very willing to finance the I.C.B.M. programme, has intervened in the dispute between the Army and Air Force regarding the most effective anti-aircraft guided missile for the defence of the United States. Up to date the Army has established sixty-two "Nike" missile battalions for the defence of key targets, equipped with the 35-mile range "Nike-Ajax" or the improved "Nike-Hercules" with a range of 75 miles. The Senate Armed Services Committee has, however, refused to vote further funds for the expansion of the "Nike" system in view of the greater range and efficiency of the Air Force "Bomarc" as a back-up for the jet interceptor. The existing version of this surface-to-air missile has a range of about 200 miles, but a new mark is under test with a reported range of over 400 miles. General Taylor, the Army Chief of Staff, strongly opposes the committee's view. He argues that anti-aircraft defence is "the Army's clearly established responsibility," and that before the "Bomarc" can assume a significant role in the defence of the United States the I.C.B.M. will be on the scene. It is, in fact, astonishing that the United States defence chiefs cannot agree on the type of anti-aircraft missile they require, despite the fact that the United States has already spent 25 billion dollars on defence against the manned bomber. Britain has deliberately taken risks in making sure that her anti-aircraft guided missile development was on the right lines before starting production. It has proved a wise policy, for the Chiefs-of-Staff are satisfied that we are now manufacturing the kind of missile best suited for this country's requirements. Indeed, as the manned bomber will still for some years yet provide the main allied deterrent, Britain might well have waited for the development of the "Polaris" before deciding on the land-based "Blue Streak"—with its very costly underground sites—in preference to a suitable ship with an armament of rockets.

The Engineer—100 Years Ago (AUGUST 26, 1859)

"ENGLISH RAILWAY ARTILLERY"

"The railways radiate from London to that piece of salt water we still call the English Channel as follows, London being the centre which in all cases the enemy would seek to possess, at all events for the purpose of plunder: The Great Western extends from London to Bristol, Exeter, Plymouth and Falmouth; the South Western extends from Exeter to Southampton, Dorchester and Bridport, with only one short link wanting; the Brighton, from London to the south coast; the South Eastern, from London to Folkestone and Dover; so including the radius south and west of the Thames. The northern bank of the Thames is closed from entrance by the North Kent and its continuations to Margate. Another South-Eastern line extends from Dover to Reigate, Guildford and Reading. Then the coast line extends again from Dover to Hythe, Rye, Hastings, Portsmouth, and continues to Dorchester, where a slip needs filling in up to Exeter, and thence the continuation goes on to Land's End. North of the Thames the lines extend from London to Tilbury, to Ipswich, Colchester, Yarmouth, Preston, Grimsby, Hull, Scarborough, and Whitby and Stockton, but which has a rear line in compensation and so on with a continuous coast line to the Firth of Forth.

"Now, all these coast railways, put to their proper uses, are really lines of defence, backed with second and third lines, and then on to a network, eclipsing any Torres Vedras on record; and having moving batteries on their lines carrying shot and shell farther than an enemy could reach, and unapproachable by cavalry, would be the cheapest of all possible fortresses—absolutely a continuous fortress along the whole coast. They would be to the land what the warship is to the sea. If we look at the rail as part of an instrument of warfare, we shall be startled at the enormous means we have at hand instantly available from mercantile purposes to convert to engines of war, and, what is more, at the economy of defence, immediately re-convertible to purposes of peace."

Sixth Congress on Large Dams, New York

A CRITICAL REVIEW OF CERTAIN SUBJECTS

By SERGE LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. I

At the Sixth Congress on Large Dams, which was held in New York in September last year, an unprecedented volume of material was dealt with. It was not possible to give a comprehensive account of all the papers read before the congress and of all the discussions which took place during its sittings. The present article describes a few of the reports submitted to the congress, which the writer found to be particularly interesting and containing the maximum of significant material. The choice is entirely personal; i.e. the reports dealt with are not supposed to be representative of all the papers read before the congress, their only distinguishing characteristics being that they appeal to the author.

Flow Pressure Pulsation and Vibration of Large Dams

THE first paper which the writer wishes to mention is due to Mr. M. A. Preobrazhensky and is entitled "Laboratory and Field Investigations of Flow Pressure Pulsation and Vibration of Large Dams." It overshadows a multitude of other interesting reports presented to the congress, and is, in a way, another case of a "sputnik" or an artificial comet.

It must be realised that for some time past "we of the West" have been aware of the birth of another significant approach to numerous problems of civil design, which following in the wake of nineteenth century concepts, were formerly dealt with on a purely static basis. In particular, this was the case with all structural works subject to the effect of a flowing liquid, be it water or air. Engineers have gradually begun to be aware that in such cases, pulsations and vibrations are of greater moment than hydrostatic loads taken alone. Until recently papers published on the subject in various periodicals were chiefly of two groups. One of them was concerned with the vibrations induced by the metal equipment of hydro-electric stations and by gates. To this group belonged, for instance, Dr. Petrikat's and the writer's own papers, published recently by *Water Power*.[1] The second group dealt with tall factory chimneys and suspension bridges. In this case, the periodicity of the induced action was the result of the formation of a trail of equidistant vortices, creating a series of shocks, following each other at constant intervals of time. Hence the vibrations.[2]

What was known about these various actions sufficed to suggest the existence of either periodic or irregularly fluctuating dynamic forces, representing the action of the flow of water on piers, sills and other elements of the structures of hydraulic works, such as dams, weirs, barrages, &c. But nothing (or very little) definite was known on the subject and the voluminous publications (*Hydraulic Research*) of the International Association for Hydraulic Research contained no reference to this particular aspect of the hydraulic science.[3] Much was done in connection with the phenomenon of cavitation, but these experiments were specifically designed to throw more light on that particular phenomenon as such, and gave, therefore, little information on the forces affecting the structure as a whole.

The foregoing brief remarks explain why, from the dozens of papers read before the congress, the writer chose this particular one as deserving special attention. In fact, it appears from this paper that the particular problem we are referring to, i.e. that of the dynamic forces due to flowing water, which need to be considered in the full stress analysis of hydraulic works, have already been, for several years, the subject of experimental investigations in no less than four independent institutions in Moscow and Leningrad. Much information is already available and a special technique and standard research methods have been developed. This material deserves to be described in these pages, as it may possibly lead to the promotion of a new branch of research in our laboratories and design offices.

Briefly stated, the problem may be presented in the form of two equations.

$$A' = f(T_0, q, h, l_0, x, ed, dc, b),$$

and

$$n = f(T_0, q, h, l_0, x, ed, dc, b),$$

in which

- A' is the maximum amplitude.
- n is the dominant frequency.
- T_0 is the total energy of flow.
- q is the specific water discharge.
- h is the downstream water depth.
- ed is the effect of the devices (i.e. baffle piers, dentated sills, &c.) used at the downstream end of the apron, to dissipate the energy of the water.
- dc is the effect of dimensional conditions, in general.
- b is the influence of fluctuations of flow upstream of the work.
- x is the distance measured downstream from the toe of the main dam (or weir) to the observation point.

In practice, equations with so many variables were found to be an unsurmountable difficulty. In order to obtain conclusive results, the experimental devices had, therefore, to be prepared on the assumption that some of the variables were constant. This gave:

$$A' = f(T_0, q, x)$$

and

$$n = f(T_0, q, x).$$

Thus, in the first stage of the investigation, the anti-scour devices were dispensed with, and the problem was reduced to a two-dimensional system. Only after these elementary relationships had been investigated was the effect of other factors attempted. These factors included the standing wave and various other artifices intended to cause energy dissipation, &c.

To measure pulsations, wire strain gauges were attached to movable diaphragms, or other devices, mounted flush with the surfaces of the hydraulic structures, i.e. piers, aprons, sills, &c. The natural vibration frequency of such devices had to be no less than 180 c/s, to avoid resonance and interference of inertia forces. For greater accuracy, the constant component of the hydraulic pressure was compensated by an air pressure applied to the inner face of the diaphragm. To give an example, an experimental device designed on these lines is shown schematically in Fig. 1.

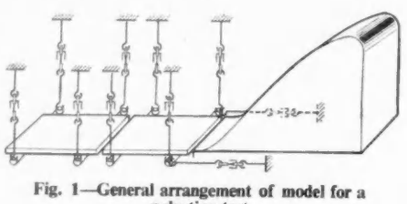


Fig. 1—General arrangement of model for a pulsation test

The object of the experiment is to discover the pulsations of water flowing over an open apron, behind a common type of weir. The movable plates, simulating the surface of the concrete apron, have the dimensions 1·0m by 0·5m. They are suspended on thin steel bands, provided with strain gauges and with screw devices for precise adjustment. Horizontal strain gauges are also arranged to measure the longitudinal component of the effect of the moving water. The gap along the plate contour is closed by means of a thin unstretched rubber band.

The natural frequency of the plates, with the water load above them, is 110 and 150 c/s in the vertical and horizontal directions respectively. These frequencies are, in this case, fully admissible, being, as they are, much higher than the observed frequencies of the pulsation of the water flow. Accordingly, there was no difficulty in calibrating the plates. The calibration characteristics were found to be linear relationships, which were fully stable.

It will be realised that Fig. 1 gives the principle only of the methods used in various tests of the same or similar categories. As is usual in modern applications of experimental science, the results thus obtained are presented in the form of dimensionless graphs. For instance, in Fig. 2 we have a graph illustrating the pulsations accompanying the phenomenon of a free (i.e. unsubmerged) standing wave.

The ordinates of the diagram are the ratios

[1] Dr. Ing. K. Petrikat, "Vibration Tests on Weirs and Bottom Gates," *Water Power*, February and March, 1958. Dr. Serge Leliavsky, "Vibrations in Hydro-Electric Installations," *Water Power*, April and May, 1957.

[2] See, for instance, F. Bleich and L. W. Teller, "Structural Damping in Suspension Bridges," *Proc. Am. Soc.C.E.*, separate No. 61, March, 1951. Also: Dockstader, Swiger and Ireland, "Resonant Vibration of Steel Stack," *Proc. Am. Soc.C.E.*, separate No. 541, November, 1954.

[3] According to the 1957 volume of this authoritative publication, vibrations induced by the flow of water were investigated in Hanover, Vienna, Rio de Janeiro and Delft, but these experiments were all concerned with the vibrations of gates, of the same type as (but less extensive than) the investigations described by Dr. Petrikat.

of the recorded amplitudes of pressure pulsations (expressed as the corresponding heights of the water column) to the total energy (i.e. difference of the upstream level and the level in the contracted section), whereas the abscissæ represent the ratios of the distances, measured along the apron, to the critical value of the depth h_{cr}. The curve

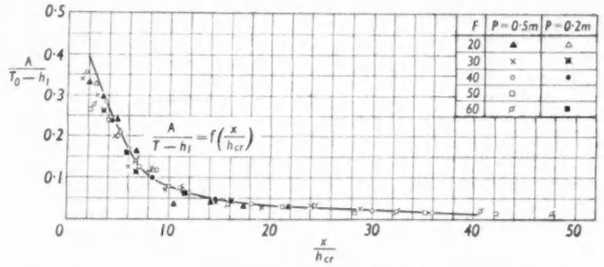


Fig. 2—Showing relation between pressure-pulsation amplitude and distance from standing wave

shows that for $x=3h_{cr}$ the pulsations attain 30 to 40 per cent of the total head, but further down the apron, at approximately $35h_{cr}$, the intensity of the pulsations falls almost to zero. This length, i.e. about $35h_{cr}$, constitutes, consequently, the length over which energy dissipation occurs.

Apart from diagrams representing graphically the results of the experiments, attempts have also been made to express these results in the form of equations ; for instance, the phenomenon illustrated in Fig. 2 is found to conform with the formula

$$\frac{A'}{h_{cr}}=1\cdot6\,F^{0\cdot67}\left(\frac{x}{h_{cr}}\right)^{-\frac{4}{3}}$$

where F is the Froude number $\frac{v_1^2}{gh_1}$ and v_1 is the velocity in the contracted section.

In a submerged wave the measured fluctuations are less pronounced than when the wave is free. For a submergence factor $D=1\cdot10$ to $1\cdot15$[4], the reduction amounts to about 20 per cent, but the effect of greater submergences is found to be rather insignificant. Fig. 3 compares the pulsations pro-

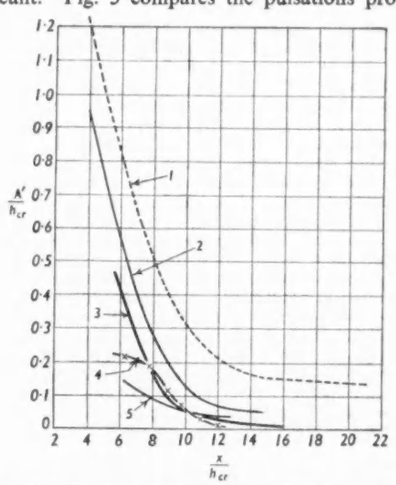


Fig. 3—Pressure pulsations behind : 1. Hydraulic jump. 2. Stilling basin (cistern). 3. Baffle piers. 4. Dentated sill. 5. Blocks

duced by various anti-scour devices, viz., as follows :—

Curve 1—Standing wave (hydraulic jump).
Curve 2—Stilling basin or " cistern."
Curve 3—Baffle piers of some size.
Curve 4—Dentated sill (Rehbock's).
Curve 5—Relatively small blocks.

[4] The submergence factor D is the ratio of the actual depth h_1 on the downstream side of the wave, and the larger of the two conjugate depths h''_1.

We have, thus far, considered local pulsations only, but it must be realised that for stress analysis in a structural member, the important point is to ascertain the average effect (if any) of the pulsating loads applied over rather large areas. Experiments show that non-coincidence of such local pulsating loads may, under certain conditions, materially reduce the total effect. In fact, synchronism of local pulsations has been detected only by those instruments, which were located at short distances from one another, in the same cross section. No coincidence was observed in pulsations recorded by apparatus arranged at various points along the same stream trajectory.

The result of the measurements of the hydraulic-load pulsations for the slab of an apron, behind a weir, is represented in Fig. 4. The standing wave is here a free wave, i.e. $D=1\cdot0$. The ordinates are the ratios T_0/h_{cr}, whereas the abscissæ represent l/l_0, in which l_0 and l are respectively the lengths of the

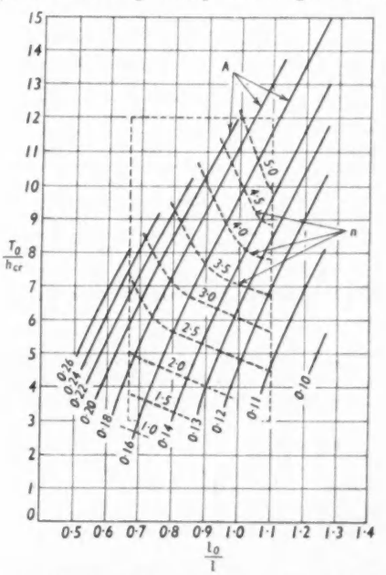


Fig. 4—Showing relation between pulsation-amplitude, frequency and other hydraulic parameters

slab and of the wave. The amplitudes A are expressed in units of h_{cr}, whilst the frequencies n are the dominant frequencies, in cycles per second. There is a linear relationship between n and the velocity in the contracted section. The non-dimensional expression for the chart is

$$\frac{v_1}{h_1 n}=f\left(\frac{T_0}{h_{cr}},\ \frac{l_0}{l}\right).$$

All the information contained in the foregoing pages refers to experimental work done in the laboratory. But Fig. 5 illustrates flow-fluctuation measurements carried out in the field. It represents the section of an actual dam which was investigated, in connection with this problem, in 1938–40. The pressure pulsations close to the crest were observed to be non-periodic, conforming generally with the normal, Gaussian frequency-distribution law. Analytical expressions were developed for the hydrodynamic effect recorded in the points I and II, as a function of velocities and discharges. In general, the maximum pulsation amplitude tends to be proportional to the square of the velocity, unless local factors introduce dif-

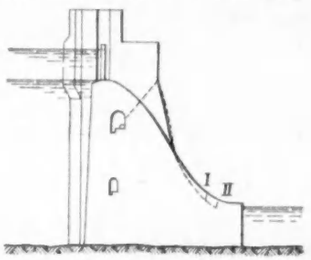


Fig. 5—Dam profile showing points where pressure-pulsation measurements were taken

ferent relationships. Also, it is frequently observed that the amplitude varies inversely as the frequency of the pulsations. For instance, for a wide-crested spillway the recorded pulsation amplitude varied from $0\cdot27v^2/2g$, at the beginning of the apron, to $0\cdot17v^2/2g$ at its end. The corresponding figures for a sharp-crested weir and aerated flow were $0\cdot20v^2/2g$ and $0\cdot11v^2/2g$. The corresponding pulsation frequencies ranged between 2·7 c/s as a minimum, and 3·7 c/s as a maximum.

The results of another set of pulsation measurements carried out at an actual dam are shown in Fig. 6. The hydraulic parameters characteristic of the case investigated were as follows :

Specific flow energy ...	$T_0=21\cdot4$m
Specific discharge	$q=23\cdot8$m³/sec.
Submergence factor of standing wave	$D=1\cdot5$
Froude number	$F=23\cdot4$
Height of antiscour lip ...	$=3\cdot0$m

As seen from the chart, the ratio of the pulsation-amplitude to the velocity-head was 35 per cent at the contracted section of the flow, fell to 9 per cent at the end of the solid apron, then rose again to 54 per cent above the lip weir and fell to 1 per cent at the tail of the solid protection of the bed of the channel. It is significant to observe that field records were in close agreement with laboratory tests. The total hydrodynamic load was 20 tons for the 30m long apron, and 3 tons for the 1m wide lip. The dominant pulsation frequency was from 5 to 6 c/s.

To obtain, as in this case, a satisfactory agreement between experiment and field results, it is essential to design the model to a specific scale, expressing the law of hydraulic similarity. In accordance with what was said earlier on the linear relationship

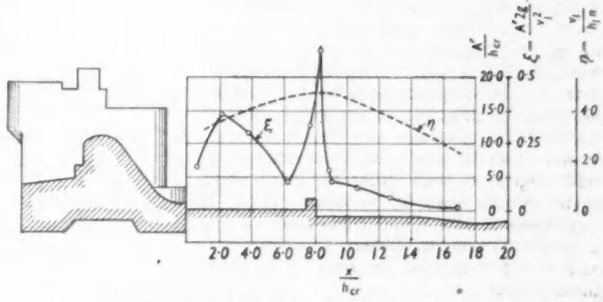


Fig. 6—Pressure pulsations downstream of a dam

between the pulsation amplitude and the square of the velocity, the basic equation is

$$\alpha_{\Delta A} = \alpha_V^2$$

in which the symbol $\alpha_{\Delta A}$ is the scale for the pressure amplitude and α_V the scale for the velocity. Further, since, according to the usual laws of hydraulic similarity, $\alpha_V = \alpha_L^{\frac{1}{2}}$ (in which α_L is the scale for the length) it follows that

$$\alpha_{\Delta A}' = \alpha_L \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which is the first formula for model experiments on pulsations. Turning, now, to the problem of frequencies, we start with

$$\alpha_t = \frac{\alpha_L}{\alpha_v},$$

and since the frequency n is the inverse to the period of one pulsation

$$\alpha_n = \alpha_L^{-\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which is the second equation for the design of the experimental apparatus for pulsation model-testing, based on the laws of gravitational similarity.

Fig. 7 represents one of the numerous experiments carried out to verify the validity of these equations. It was conducted with three similar "models" of different sizes, the longitudinal scales being respectively 1 : 1, 1 : 2 and 1 : 3. In all three cases, the discharge took place from behind a gate. In the right-hand chart the pulsation - amplitudes and the squares of the corresponding discharges are recalculated according to equation (1) and reduced all to the scale of the larger model. The fact that the average straight line is an excellent fit for the experimental points obtained in this manner, confirms the scale formula (1).

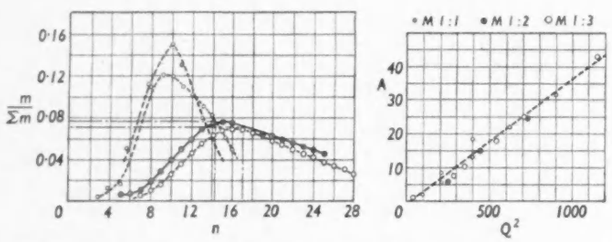


Fig. 7—Showing relation between pressure pulsations and model scale

The frequency curves appearing in the left-hand diagram in the same drawing show experimental curves for the three models, at two different gate openings. The observed pulsation frequencies are recalculated in this diagram using respectively the factors $\sqrt{1}$, $\sqrt{2}$ and $\sqrt{3}$. The close coincidence between the results, obtained in this manner with three similar models of different sizes, supplies uncontrovertible evidence, confirming the scale equation (2).

Attention will now be called to the fact that all the foregoing information refers to the hydraulic side of the problem, that is to the pulsations and vibrations as they occur in the flowing medium—the water. It is now necessary to consider the structural aspect of this problem and to ascertain to what extent these phenomena affect the design of structural works, such as dams, weirs, barrages, &c. With this object in view various vibrometers were used, incorporating the principle of the conversion of mechanical oscillations into electric current. It was usual to place three instruments at right angles to each other at every point where records were to be taken. Also, in some cases it was found convenient to use coupled instruments, having the same frequency and connected in series to the same galvanometer.

As a general conclusion, it appears that structural vibration is chiefly dependent on the mass and velocity of the jet of water impinging on the downstream face and apron of the structure, be it a dam, a weir, or a barrage. Regular harmonic vibration has so far not been observed. Oscillations with greater amplitudes possess, usually, lower frequencies. The following table permits a comparison to be made between the vertical, longitudinal and transverse oscillations recorded on three dams, built on three different types of foundations.

Dams	Foundations	Ratios of oscillation components		
		Longitudinal to transverse	Vertical to transverse	Vertical to longitudinal
First ...	Semi-rock ...	2	0·5	0·3
Second ...	Moraine loam	1·3	1·3	1·0
Third ...	Sand	1·7-2·4	5·5-7·1	3·2

The observed amplitudes recorded at two different points on the third of these dams are shown in Fig. 8 as functions of the discharge, as follows :

Curve 1—Vertical component. Gallery.
Curve 2—Longitudinal component. Gallery.
Curve 3—Longitudinal component. Bridge.
Curve 4—Transverse component. Gallery.

Fig. 9 compares the vibrations recorded on the three dams, the specific discharge being taken as the basis for this comparison.

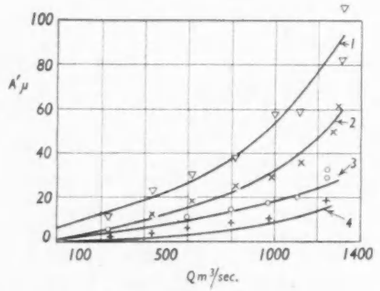


Fig. 8—Showing relation between dam vibration and discharge

The curves in the drawing show vibrations measured at :

Curve 1—Third dam, 21m above foundation level.
Curve 2—Second dam, 26m above foundation level.
Curve 3—First dam, 45m above foundation level.

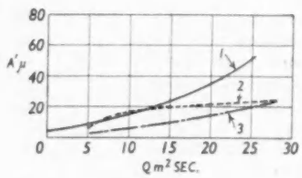


Fig. 9

It must be realised that whilst the entire structure vibrates, each one of its numberless points travels along a certain trajectory, which is characteristic of the local conditions of the particular element to which it belongs. It is also fairly obvious that these trajectories are one of the main considerations in assessing the safety factor of the structure.

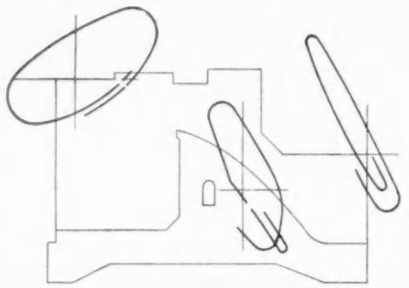


Fig. 10—Trajectories of vibrating motion for various points of a pier

Examples of such trajectories descriptive of one single oscillation of a dam structure are shown in Fig. 10 to a very much exaggerated scale of course.

In concluding the present section of this article, it is hoped that the information contained therein may, perhaps, induce other universities and scientific laboratories to carry out similar work, which would certainly greatly benefit the profession.

(To be continued)

Proposed Instrument Factory of Anti-Clastic Shell Construction

WHEN the first plant of Texas Instruments, Ltd., the British associate of Texas Instruments, Incorporated, was opened at Dallas Road, Bedford, in October, 1957, it was foreseen that a much larger area would be required within three years to house the expanding production lines for the company's silicon semi-conductor devices, and the staff engaged in research, circuit applications, engineering product development and administration. A new plant is therefore to be built at Manton's Lane, Bedford, and is due to be occupied in the autumn of 1960. This will total 125,000 square feet, nearly treble the existing area and seven times the area first occupied by Texas Instruments, Ltd., twenty-two months ago. Plans are also in hand for two further stages which will double this area.

Two forms of concrete construction, comparatively new in Great Britain, will be used in the building programme. The roof of the production area will be composed of hyperbolic paraboloid shells, whilst its floor, together with the upper floors and roof of the office block will be cast at ground level and raised into position by the "lift slab" method. The roof shells will be grouped into squares, each with a side length of 48ft in plan, each group being supported solely by a hollow concrete column at its centre point.* The hollow column will also serve as a rainwater drain, and wood-wool panels between shells will give a column spacing of 50ft.

The company's consulting engineers, Messrs. Oscar Faber and Partners, who are working in conjunction with O'Neil Ford and Richard Colley of America, consulted the Cement and Concrete Association, and the Association's research station has made and tested a one-eighth scale model of the basic "square" of four shells. In particular, information was sought on deflections caused by eccentric loads. Further tests on the model, which will eventually be tested to destruction, are proceeding as part of the Association's general research programme in this field.

* See "The Engineer," May 15 last, pages 770 and 771, for a description of this type of construction.

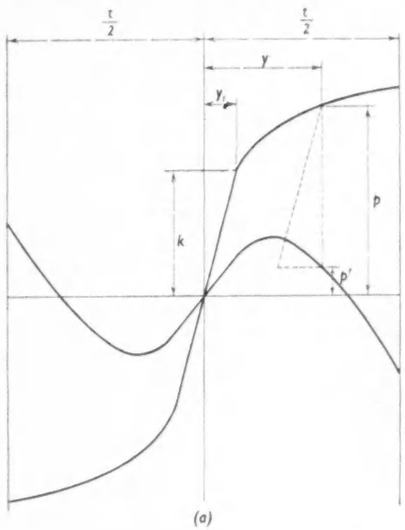
Spring-Back and Stretch-Forming of Sheet Metal

By D. M. WOO* and J. MARSHALL†

The forming of sheet metal strips into plain curved parts has many applications, particularly in the aircraft industry. The knowledge of spring-back of metal associated with this type of forming is essential when designing the tools so that the contour of the product can be formed accurately. In the case of forming by pure bending, the problem of spring-back has been investigated on various occasions,[1, 2, 3] and in particular, Gardiner has obtained a simple expression for spring-back by assuming a stress-strain curve with a constant yield stress for the material. Taking into account the strain-hardening characteristic of the material, this paper derives an equation for spring-back by assuming a simple power law for the stress-strain relationship of the material in the plastic range, and the equation is further simplified by approximating the relationship in a linear form. From the results presented by Gardiner, it can be expected that the derived equation should give accurate results particularly for materials showing a strong strain-hardening characteristic. In the case when the ratio of forming radius to metal thickness is large, the spring-back is severe and has to be reduced by applying a tensile force at each end of the metal strip. The process is known as stretch-forming. Some typical examples of machines designed for such purpose have been described by Edwards.[4] This paper analyses the stress and strain conditions in the material during the operation, and an expression for spring-back ratio is derived. The analysis has been verified by experiments.

(1) Spring-Back in Pure Bending

USING the assumptions as for elastic bending, the stress and strain distributions before and after removal of the external moment are as shown in Fig. 1 (*a*) and (*b*), where K is the yield stress for the material, t the metal thickness, p and e the stress and strain under bending in a fibre at a distance y from the neutral axis, and p' and e' the residual stress and strain in the same fibre. For the condition of moment equilibrium,



(*a*) Stress distribution. (*b*) Strain distribution.

Fig. 1—Stress and strain distributions across the section of the metal strip in pure bending

$$\int_0^{t/2}[p-E(e-e')]y\,dy=0 \quad . \; . \; (1)$$

Now

$$e-e'=\left(1-\frac{R}{r}\right)\frac{y}{R} \quad . \; . \; . \; (2)$$

where R and r are the radii of the neutral fibre before and after the spring-back.

From (1) and (2), it follows that

$$\frac{R}{r}=1-\frac{24R^3}{Et^3}\int_0^{t/2R}pe\,de^2 \quad . \; . \; . \; (3)$$

If the stress-strain curve in the plastic range can be represented as

$$p=K+A(e-e_1)^n \; . \; . \; . \; . \; (4)$$

where K is the yield stress, A and n the constants, and $e_1=K/E$, then

$$\int_0^{t/2R}pe\,de^2=\int_0^{e_1}Ee^2de+\int_{e_1}^{t/2R}[K+A(e-e_1)^n]e\,de^2 \; . \; (5)$$

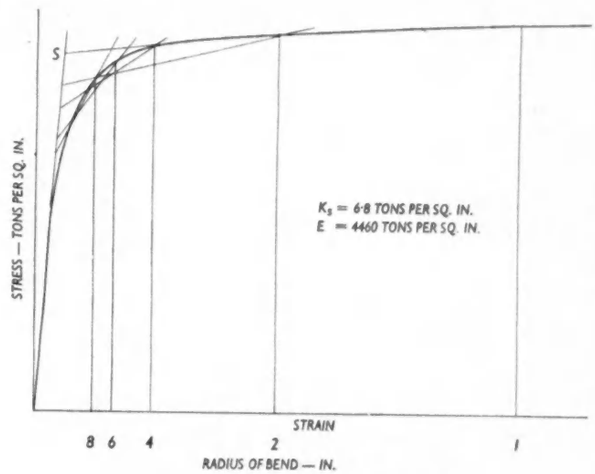


Fig. 2—Stress-strain curve for aluminium

By integrating (5) and substituting it into (3), the following can be obtained :

$$\frac{R}{r}=1-3\left(\frac{KR}{Et}\right)+4\left(\frac{KR}{Et}\right)^3-\frac{24R^3A\left(\frac{t}{2R}-\frac{K}{E}\right)^{n+1}}{Et^3(n+1)(n+2)}\left[(n+1)\frac{t}{2R}+\frac{K}{E}\right] \quad . \; . \; . \; . \; . \; (6)$$

If the above stress-strain curve is approximated in the form :

$$p=K+H(e-e_1) \; . \; . \; . \; . \; (7)$$

then with $A=H$ and $n=1$, (6) is reduced to

$$\frac{R}{r}=\left(1-\frac{H}{E}\right)\left[1-3\left(\frac{KR}{Et}\right)+4\left(\frac{KR}{Et}\right)^3\right] \quad . \; (8)$$

For $H=0$, (8) becomes identical to Gardiner's equation.

The accuracy of (6) or (8) depends on the closeness of the assumed stress-strain curve to the actual one. For most materials, (4) gives good approximation to the actual stress-strain curve particularly within a small range of strain. Thus for large ratio of bend radius to metal thickness, accurate results can be obtained by using (6). However, if the stress-strain curve is approximated in a linear form, the calculation for the spring-back is simplified by adopting (8). It may be noted that for each radius, the maximum strain $t/2R$ is first determined and the values of H and K are then approximated as illustrated in Fig. 2. Equation (8) improves Gardiner's expression and should be particularly useful in estimating the spring-back of metal which shows a strong strain-hardening characteristic.

(2) Spring-Back in Stretch-Forming

The metal strip is stretched and bent over a block of radius R_1 under a constant tensile force. Fig. 3 (*c*) represents an elementary length L_0 of the strip when being stretched and bent. In relating to the strain $e_{m_2}=\delta L_{m_2}/L_0$ in the inner surface m of the strip, the strain in a fibre at a distance y from m is

$$e_2=e_{m_2}+(1+e_{m_2})\frac{y}{R_1} \quad . \; . \; . \; (9)$$

The stress distribution is shown in Fig. 3 (*a*) or (*b*) depending on the magnitude of the tensile force. If p_1, e_1 are the uniform initial stress and strain respectively in the section, then after bending the positions of y_{c_2} and y_{d_2} where the fibres are stressed to the yield point K are, as Fig. 3 (*a*), for y_{c_2}

$$Ee_{c_2}=-K$$

hence

$$y_{c_2}=\frac{-(K+Ee_{m_2})R_1}{(1+e_{m_2})E} \quad . \; . \; . \; (10)$$

for y_{d_2}

$$Ee_{d_2}=K$$

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† Department of Mechanical Engineering, Sheffield University

hence

$$y_{d_2}=\frac{(K-Ee_{m_2})R_1}{(1+e_{m_2})E} \quad . \quad . \quad . \quad . \quad (11)$$

The stresses at the inner and outer surfaces are respectively,

$$p_{m_2}=-K+H(e_{m_2}-e_{c_2})=-K-H(1+e_{m_2})\frac{y_{c_2}}{R_1} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

and

$$p_{n_2}=K+H(e_{n_2}-e_{d_2})=K+H(1+e_{m_2})\frac{t-y_{d_2}}{R_1} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Now

$$\frac{p_{n_2}-p_{m_2}}{2}[t-(y_{d_2}+y_{c_2})]=p_1 t \quad . \quad (14)$$

By substituting (10), (11), (12), and (13) into (14), and approximating $(1+e_{m_2})$ to unity, the following can be obtained :

$$e_{m_2}=\frac{t}{2R_1}\left[\frac{p_1}{K+H\left(\frac{t}{2R_1}-\frac{K}{E}\right)}-1\right] \quad . \quad (15)$$

Thus by determining e_{m_2} from (15), the stress and strain values in any fibre in the section can be calculated. The stress condition across the section is thus as follows :

between $m2$ and $c2$,

$$p_2=-K-H(1+e_{m_2})\frac{y_{c_2}-y}{R_1} \quad . \quad . \quad (16)$$

between $c2$ and $d2$,

$$p_2=Ee_{m_2}+E(1+e_{m_2})\frac{y}{R_1} \quad . \quad . \quad . \quad (17)$$

and between $d2$ and $n2$,

$$p_2=K+H(1+e_{m_2})\frac{y-y_{d_2}}{R_1} \quad . \quad . \quad . \quad (18)$$

After removing the external forces, the metal springs back to a radius of r_1, and the strain of a fibre at a distance y from the inner surface of the strip is then

$$e_3=e_{m_3}+(1+e_{m_3})\frac{y}{r_1} \quad . \quad . \quad . \quad . \quad . \quad (19)$$

From (9) and (19), the change of strain is

$$e_3-e_2=(e_{m_3}-e_{m_2})+\left[\frac{(1+e_{m_3})}{r_1}-\frac{(1+e_{m_2})}{R_1}\right]y \quad . \quad . \quad . \quad . \quad . \quad (20)$$

The residual stress is then represented generally as

$$p_3=p_2+E(e_3-e_2) \quad . \quad . \quad . \quad . \quad (21)$$

From the condition $\int_0^t p_3 dy=0$ and using (10), (11), (20), and (21), it can be shown that

$$e_{m_3}\left(1+\frac{t}{2r_1}\right)=e_{m_2}+\frac{t}{2R_1}(1+e_{m_2})-\frac{t}{2r_1}-\frac{p_1}{E} \quad . \quad . \quad . \quad . \quad . \quad (22)$$

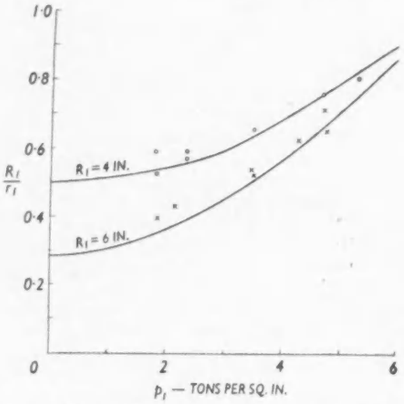

Fig. 4—Spring-back correction for stretch-forming

and from the condition $\int_0^t p_3 y dy=0$,

$$e_{m_3}\left(1+\frac{2t}{3r_1}\right)=e_{m_2}+\frac{2t}{3R_1}(1+e_{m_2})-\frac{2t}{3r_1}-A \quad . \quad . \quad . \quad . \quad . \quad (23)$$

where

$$A=\frac{K}{E}\left\{1-2\left(\frac{1}{1+e_{m_2}}-\frac{R_1}{t}\right)^2\left[\frac{1}{3}\left(\frac{K}{E}\right)^2+e_{m_2}^2\right]\right\}+\frac{H(1+e_{m_2})}{3ER_1t^2}(y_{d_2}^3-3y_{d_2}t^2-y_{c_2}^3+2t^3) \quad . \quad . \quad . \quad . \quad . \quad (24)$$

By solving (22) and (23), a general equation for the spring-back ratio in stretch-forming can be obtained as

$$\frac{R_1}{r_1}=\frac{\frac{1}{6}(1+e_{m_2})+\frac{R_1}{t}\left(\frac{p_1}{E}-A\right)}{\frac{1}{6}(1+e_{m_2})-\frac{2p_1}{3E}+\frac{A}{2}}\simeq 1+\frac{6R_1}{t}\left(\frac{p_1}{E}-A\right) \quad . \quad . \quad . \quad . \quad . \quad (25)$$

where A and e_{m_3} can be determined from (10), (11), and (15). The calculation can be simplified by assuming $H=0$, and thus

$$A\simeq\frac{K}{E}\left\{1-2\left(\frac{R_1}{t}\right)^2\left[\frac{1}{3}\left(\frac{K}{E}\right)^2+e_{m_2}^2\right]\right\} \quad . \quad . \quad (26)$$

If the value of p_1 is such that the stress distribution is as shown in Fig. 3 (*b*), then the following equations can be similarly derived,

$$e_{m_2}'\simeq\frac{K}{E}-\sqrt{\frac{2t(K-p_1)}{R_1E}} \quad . \quad . \quad (27)$$

$$A'\simeq\frac{K}{E}-\left(\frac{K}{E}-e_{m_2}'\right)\left(\frac{y_{d_2}}{t}\right)^2+\frac{2y_{d_2}^3}{3R_1t^2} \quad . \quad . \quad . \quad . \quad . \quad (28)$$

The spring-back equation is the same as (25).

Experimental work has been carried out on aluminium strips of 0·035in thick having a stress-strain curve shown in Fig. 2. Two punches of 6in and 4in radii were used. The angle of contact between the test strip and the punch was small so that variation of tension along the strip could be neglected[5] and the radius of curvature after spring-back could be assumed uniform. As shown in Fig. 4, analytical results calculated with $H=0$ correlate well with experimental values except when the superimposed tension is low resulting in strong spring-back. The discrepancy can be reduced by finding from the stress-strain curve the value of H for each value of p_1 as described previously in the case of pure bending. In practice, however, the superimposed tension is usually high enough to reduce the spring-back effectively, and the calculation can thus be much simplified by assuming $H=0$.

The residual stress p_3 can be found by using (20), (21), and (22), and can be shown as

$$p_3\simeq(p_2-p_1)+E\left(\frac{1}{R_1}-\frac{1}{r_1}\right)\left(\frac{t}{2}-y\right) \quad . \quad . \quad . \quad . \quad . \quad (29)$$

where p_2 can be determined by using (16), (17), and (18), and r_1 by (25). Fig. 5 shows the residual stress distribution for R_1 of 8in for each value of p_1. The condition of zero resultant force and zero resultant moment across the section of the strip are shown to be fulfilled.

The authors wish to thank Mr. N. S. Ali for his assistance in computations and experimental work.

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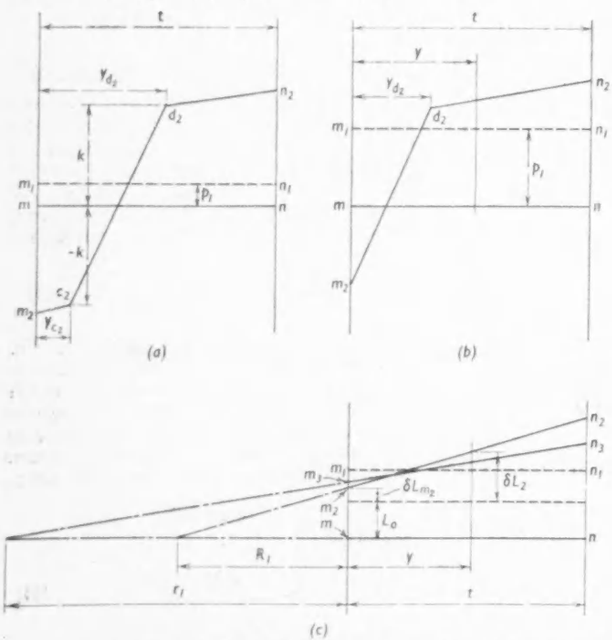
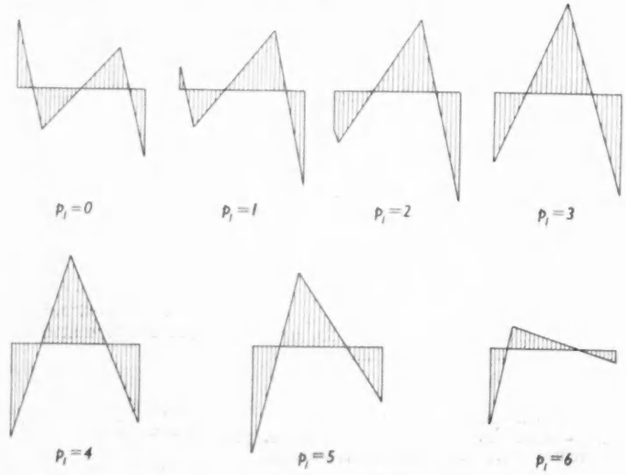


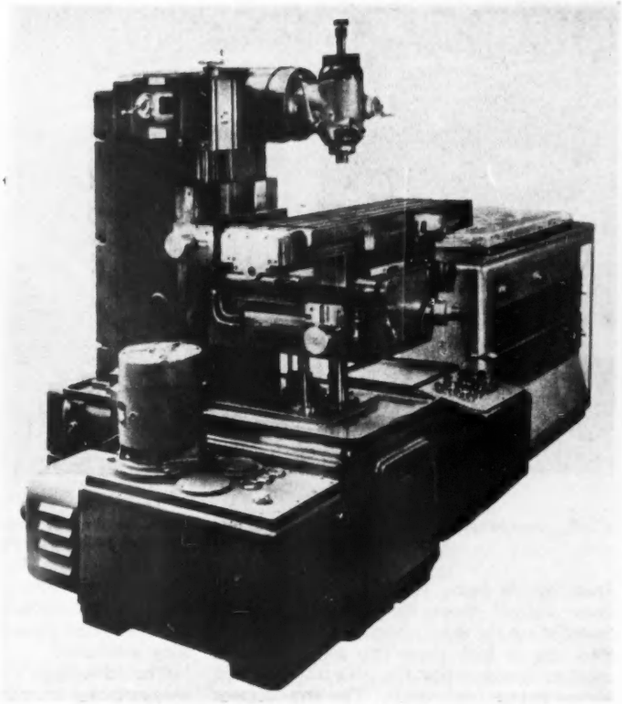
Fig. 3 (*a*) and (*b*)—Stress distribution across the section of the metal strip in stretch-forming ; (*c*) An elementary length of the strip under stressed condition



$H=0$; $K=6·2$ tons per square inch ; $E=4460$ tons per sq. inch.

Fig. 5—Residual stress distribution across the section of the strip

Automatic Control Systems for Machine Tools



Two new systems of automatic control for machine tools which have been introduced by Ferranti, Ltd., are designed to provide simple, reliable and easily maintained equipment at a price within the reach of the smaller as well as the larger engineeering firms. These systems comprise a transistor-hydraulic continuous control and a numerical positional control. They are to be demonstrated for the first time at the European Machine Tool Exhibition in Paris. A precision milling machine with Ferranti three-dimensional control equipment is illustrated on the right.

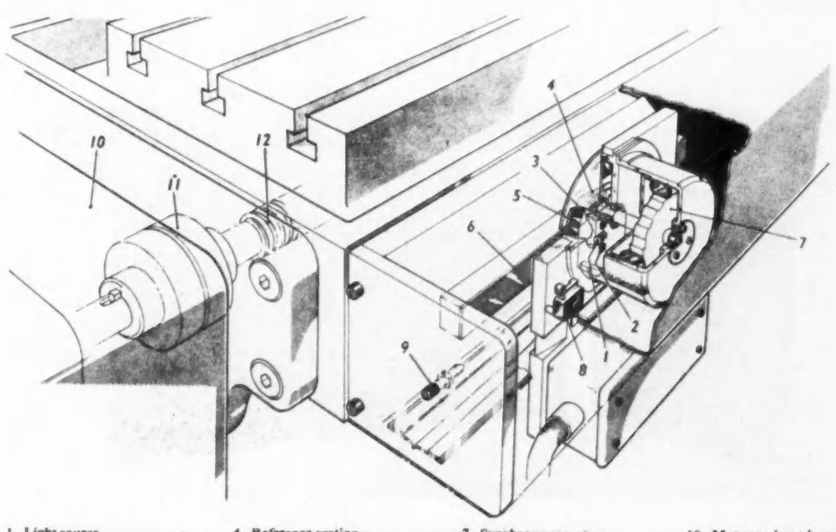
WE recently attended demonstrations of two new systems of automatic machine tool control developed by Ferranti, Ltd., Hollinwood, Lancs, with a view to providing equipment economically suitable for use on machines in small as well as large engineering establishments. One of these systems, using magnetic tape, provides continuous control and operates from normal electricity mains supplies. It is fully transistorised and incorporates hydraulic servo-mechanisms with a simplified measuring system. In it hydraulic piston motors with a peak output of 3 b.h.p. are controlled by electro-hydraulic valves, and simplified transistor circuitry for each function of the machine tool is contained in three replaceable trays in the control console. The second system provides a numerical positional machine tool control equipment for rapid point-to-point setting in Cartesian or polar co-ordinates, using information provided on punched paper tape. Alternatively, incremental movements can be effected by direct dial setting without the use of punched tape.

In presenting this new Mark IV equipment the makers point out that in its previous Mark III equipment the magnetic tape playing time at 15in per second restricted the time to twenty minutes with an 1800ft long tape or forty minutes with a 3600ft tape. The limitation which necessitated the speed of 15in per second was one of pulse packing density, which cannot be increased substantially beyond 150 pulses per inch if a tape is to be used under workshop conditions. To achieve an economy in tape speed, the system of recording required to be changed, and for the new equipment it was determined that the required resolution could be obtained at lower speeds by the use of a phase displacement carrier system, in which the control information is recorded as discrete displacements in phase between a series of control pulses and a pulse train recorded as a reference channel. The frequency of recording is now 208 pulses per second and, after recording, the waveforms are reshaped to give square-waves with a frequency of 104 c/s.

When no machine movement is demanded and the system is at datum, signals on all four tracks of the tape are identical and in phase. Should movement be demanded on any channel, the signals on this channel undergo a progressive positive or negative displacement in phase, depending on the direction and speed of motion. These signals can be recorded and resolved satisfactorily at a tape speed of 3·75in per second. A considerable economy in tape is thus made and with the new equipment a 3600ft tape has a playing time of 190 minutes.

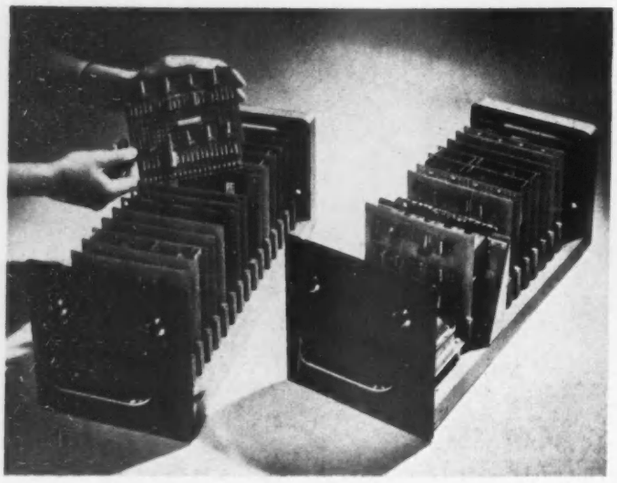
Measuring System

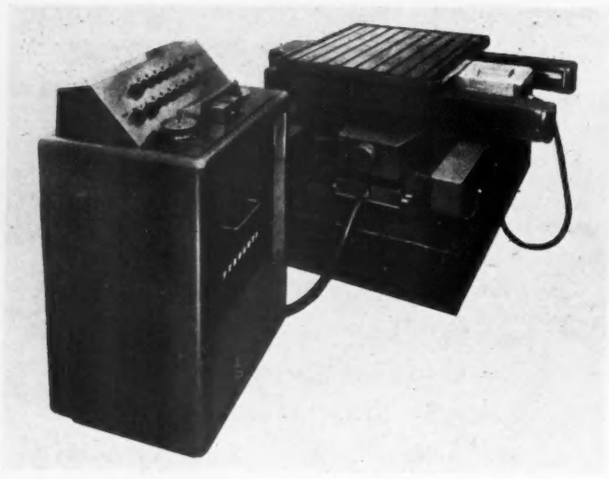
This type of recorded information demands feedback information in similar form if control simplicity is to be preserved, and for this reason a new method of using the Ferranti diffraction grating measuring system was developed. It will be recalled that this measuring system is based on the fact that a pair of crossed diffraction gratings, moving relatively to one another, can be made to generate a multi-phase electrical system in which the total number of cycles is a measure of the distance moved, the frequency a measure of the velocity and the direction of phase rotation a measure of the direction of the movement, the carrier frequency being zero. If the carrier frequency is made not zero, but 104 c/s, by arranging that the grating which was previously fixed scans steadily across the field at a speed of 104 lines per second, the system behaves much as before, except that the change in frequency when external movement occurs is above or below the carrier instead of on either side of zero. This frequency may be compared with a reference generated by the addition of a further section of fixed grating also scanned by the continuously moving grating, the light variations from this system being read by a separate photocell. Thus, if the external displacement is zero and at datum, both photocells give outputs of the same frequency and phase ; when external movement occurs, the signal output acquires a progressive phase displacement with respect to the reference,



1. Light source.
2. Photo cells.
3. Collimating lens.
4. Reference grating.
5. Scanning grating.
6. Moving grating.
7. Synchronous motor.
8. Limit switch.
9. Limit stop.
10. Motor and gearbox.
11. Coupling.
12. Lead screw.

Driving and measuring equipment for continuous machine tool control system





(Left) Transistor circuitry for control console assembled in the form of plug-in cards housed in removable trays. Workshop servicing is carried out by replacing a complete assembly (Right) Numerical positioning control system as applied to the "Atlantic" co-ordinate table

these signals being of the same nature as those derived from the command signals recorded on the tape. The servo-mechanism used has to lock these two sets of signals together to ensure that the table displacement obeys the tape commands. The arrangement of the mechanism can be seen in a drawing we reproduce.

Scanning is effected by a rotating disc which has a multi-start spiral recorded on it as a black pattern on clear glass. This disc is driven from the reference signal on the tape by a synchronous motor, the combination of motor poles and spiral starts forming an electro-optical gear to give the correct scanning frequency in lines per second. To eliminate any possible error due to departures from perfection of the scanning system and its drive, the reference signal from the scanning unit is utilised in a manner which compensates for such errors. The opportunity has been taken of using reflection gratings engraved on stainless steel strip which has a coefficient of thermal expansion very close to that of the materials used for machine tool construction. This design gives a compact system which is easily fitted to machines and which eliminates the elaborate mounting procedures necessitated by temperature changes when glass gratings are used on very long machines.

The advantages claimed for this system of measurement are that there are substantially no manufacturing limitations on the grating pitch, so that a flexible choice can be made between accuracy of phase comparison and fundamental grating pitch. It is comparatively easy to phase-synchronise two square-wave signals to an accuracy of 1 or 2 per cent. If, therefore, a measurement accuracy of 0·0001in or 0·0002in is required, a suitable grating pitch would be 100 lines per inch.

The square-wave signals from the control tape and the grating measuring system are phase-synchronised in a specially designed phase comparator, which has an accuracy of 1 part in 500 and gives an output error signal to the servo amplifier and thence to the electro-hydraulic servo-valve.

Servo-Mechanisms

For the hydraulic servo-mechanisms there has been designed a standard 3 b.h.p. peak motor and gearbox unit, which is adaptable for fitting to many types of machine tool. This unit has a very low compliance and zero backlash and can extract all the performance of which the machine tool structure is capable in terms of acceleration and accuracy of position. It is a complete assembly containing motor and control valve and oil filter. Oil is supplied to the system at a pressure of 1500 lb per square inch from an auxiliary off-loading pump unit. A stalled torque of 1000 lb in and a top speed of 60 r.p.m. is available with the standard ratio at 1500 lb per square inch. In some cases it is possible to take advantage of the existing hydraulic installation on a machine tool—which greatly simplifies the application of controls and reduces the cost substantially. The Hayes vertical milling machine illustrated at the head of this article is an example of linking the new three-dimensional control equipment with the hydraulic installation on a machine, which in this case was specially developed for the purpose.

Precision two-dimensional profiling machine designed especially to operate in conjunction with control systems for profile cutting templates and cams

Control Console

The use of transistors and semi-conductors as circuit elements in the control equipment has enabled the size of the control unit to be restricted and a complete control channel is now contained in a single drawer 7in square by 18in long. On the front of each control channel drawer is a red light which goes on should a fault occur in that channel, and simultaneously zero speed is demanded from the servo and the machine is shut down. "Reset" and "Test" buttons are provided but if the fault persists the drawer can be interchanged with a spare contained in the console and work resumed. In addition to the (normally) three control drawers, a reference drawer is provided containing the equipment to synchronise the scanning motors from the reference track on the magnetic tape. This equipment includes provision to switch over automatically to the internally generated reference signal when the tape is stopped and allows full manual control to be obtained over the servo-mechanism and measuring loop, enabling the machine slides to be moved under the control of push buttons or vernier control knobs as required.

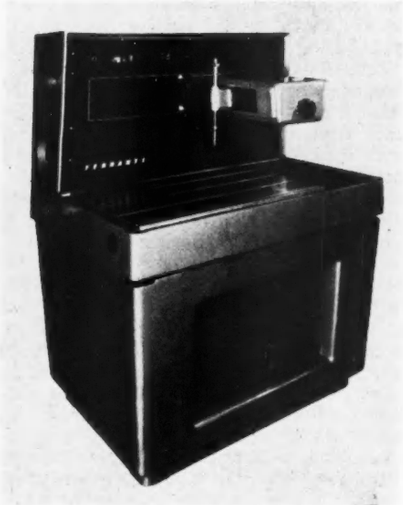
The power supply for the whole equipment consists of two 12V lead-acid accumulators, fitted with "Catylators" which reduce to negligible proportions the loss of water in the form of gases, as the hydrogen and

oxygen emitted are combined and returned as water. The batteries are maintained on continuous float charge from a charger and this form of power supply has the advantage that the voltage provided is inherently stable and power is available at very low impedance, unaffected by interruptions and noise from the mains supply.

Automatic Checking

On the Mark III control equipment a fourth checking track was provided on the magnetic tape and used to check for tape drop-outs and the whole operation of the control equipment. In the new equipment this is no longer required as the system is inherently insensitive to tape drop-outs because of the continuous cyclic nature of the recorded signals. Also, in the event of a deviation from the true position occurring the absolute position is not lost until the error has exceeded half a grating pitch. Provision is made in the phase comparison system for a fault signal to be produced which shuts the machine down and operates the appropriate fault indicator lamp should the phase comparison be in error by a preset amount up to a quarter of a grating pitch. This system provides protection identical with the automatic checking which is a feature of the Mark III equipment.

In the "Contourmatic" profile milling machine made by High Precision Equipment, Ltd., shown in another of our illustrations, the continuous control system was integrated with the machine from the initial design stages. It has been developed for the rapid manufacture of precision flat contoured workpieces, templates, cams and similar work. The spindle head through its slides has a longitudinal traverse of 48in and a cross traverse of 12in under the continuous control system, the cutter height setting being hand-operated with reference to precision scales. In the longitudinal direction the spindle traverse is effected by a recirculating ball screw and nut driven from the standard Ferranti hydraulic servo-mechanism as described above. In the transverse direction the head is moved by a hydraulic ram and electro-hydraulic servo-valve arrangement. The spindle is driven by a 3 h.p. hydraulic motor and has a stepless speed range from 260 to 4500 r.p.m.; the spindle head feed rates are variable up to a maximum of 36in per minute.



Co-ordinate inspection machine which provides a rapid means of inspection of components to an accuracy of 0·001in

Numerical Position Control Equipment

The Ferranti numerical position control equipment, for rapid point-to-point positioning of machine tools and allied equipment in Cartesian or polar co-ordinates, is arranged for use with a co-ordinate table in the illustration opposite. With it the measurement of position is by use of the diffraction measuring system. The electronic control equipment is designed around semiconductors, and a new clutch servo-mechanism has been developed for use with the equipment, although, for special applications, the equipment can be used with any servo-mechanism in the range. A tape reader, developed for the information input, uses standard $\frac{1}{2}$in wide punched tape, but instead of the usual system of sequential reading of single characters, a whole block of information is read at a single position. This minimises the time taken to transfer the co-ordinates into the control system and obviates the need for additional information storage.

The tape reader, manual co-ordinate-setting dials, numerical read-out indicators (if provided), all electronic equipment and power supplies are assembled in a floor-standing console to be seen at the side of the demonstration table in our illustration. The reader has a tape spooling equipment which has feed and take-up spools accommodating 200ft of tape, which is sufficient for 600 three-dimensional position movements. The use of tape or dial input can be selected as required. Information space is provided on the tape for controlling machine functions other than positioning, so that a complete operating cycle such as drilling can be controlled.

The electronic equipment is built in the form of plug-in "cards," accessible behind a drop-down panel at the front of the console. Only four types of "card" are used and servicing is rendered extremely simple, an indicator lamp on the panel being actuated by the automatic error-check system to indicate a faulty channel. Only semi-conductor circuits are used in the equipment, which is based on a newly-developed high-speed transistor decimal counter provided with a continuous ternary checking circuit. This counter keeps a continuous record of the position of the machine slide from an arbitrary datum, which can be changed at any time and set to any point on the table. The input position is selected by tape or dials, a direction discriminator deciding whether the co-ordinate in the counter is higher or lower than the demanded position and selecting the direction of movement to bring the table position into coincidence with the setting.

The decimal counter is continuously checked by means of the ternary logic, so that in the event of a failure the equipment stops automatically and will not function again until the defective circuit card has been replaced or repaired; thus, there is no possibility of an incorrect setting due to failure. In addition, a similar check is applied to the tape-reading equipment to obviate misreading the punched tape.

For the measuring system gratings, either linear or circular and of pitch suitable for the accuracy required, are fitted to each axis of the machine, rendering the accuracy independent of the lead screws or other transmission elements.

The servo-packs actuating the motions each have a 50 c/s induction motor and two control clutches and gearing to give a two-speed drive. Through these drives fast approach speed up to 200in per minute can be provided, depending on the resolution required, and a final slow setting speed brings the table to rest at the correct setting two or three seconds after the changeover is made. At the point of setting, the slides are automatically clamped.

Co-ordinate Inspection Machine

A further Ferranti development is the new co-ordinate inspection machine illustrated, which is designed to provide a rapid means of inspecting machined components to an accuracy of 0·001in. It replaces conventional inspection methods with dial gauges, slips or height gauges on a surface table. Parts are placed on the table and the probe on a head is positioned at the required hole centres or points for checking. Working from a datum and sliding the probe head to the various required points, a direct reading to three places of decimals is taken of each point on the x and y axes, and displayed in illuminated panels in the face of the rear panel. At the right of each illuminated panel a plus or minus which is displayed at each reading shows if the fourth decimal place would be over or under 0·0005in in dimension.

The probe can be fitted with interchangeable tips to suit the class of work and its head is supported from a rigid cantilever beam projecting over the work table. This beam moves longitudinally on slides along the back panel of the machine over a length of 24in for the x axis, and for the y axis the probe head has a movement of 15in along the beam in the transverse direction. The probe has a vertical movement of 10in in the head and is spring-loaded in the upwards direction.

Electro-optical sensing units are fitted to the slides of the x and y axes, and motion along either axis causes the Moire fringe pattern generated by the associated diffraction gratings to traverse photocells. In these photocells changes in light intensity are converted into their electrical counterpart and transistor bi-directional decade counters record the cyclic variation. As information of measurement this record for each axis is displayed continuously on two five-figure electronic counter banks for the position of the probe to be read-off directly to an accuracy of 0·001in.

Colloquium on the Shaping of Sheet Metal

A Colloquium on Sheet Metal Forming, with special emphasis on methods of testing, organised jointly by the Société Française de Métallurgie and the International Deep Drawing Research Group (I.D.D.R.G.), will be held in Paris from May 23 to 25, 1960 inclusive. Provisionally, the programme will cover theoretical studies of sheet metal forming and the materials used in sheet forming (half a day); sheet metal forming (whole day); and new techniques of sheet metal forming (half a day). Authors who wish to present a paper should send both the title and a brief summary to the Secretariat before November 1, 1959. The exact programme may be subject to revision and the number of papers selected has to be limited. The organising committee will decide on its choice of papers and the committee will inform the respective authors of its decision before December 1, 1959. The completed or provisional texts of the selected papers should be in the hands of the organising committee before February 15, 1960. The text of the articles or papers must be in one of the three official languages: French, English or German. The text should be prefaced with a brief summary in each of the three languages. Offers of papers or requests for further information should be made to either member of the joint Secretariat named below: S.F.M.: M. M. Dupont, sécrétaire-général de la Société Française de Métallurgie, 25, rue de Clichy, Paris 9 éme; I.D.D.R.G.: Dr. S. Garber, B.I.S.R.A. Laboratories, Hoyle Street, Sheffield, 3, Yorks (England).

Simplified Small Car

A saloon car smaller and much more compact than present B.M.C. models has been put into production and included in both Austin and Morris ranges. An existing engine in short-stroke form fits directly on top of the transmission and drives the front wheels. Springs and dampers are telescopic, the former being of rubber and having very small deflections.

THERE has been announced by the British Motor Corporation a new small car which will be included among both the Austin and the Morris ranges, under the names of "Seven" and "Mini Minor," respectively. The designer is Mr. A. Issigonis, who designed the current "Minor," and the mechanical arrangement closely follows that of the older design in such details as the use of suspension geometries with links loaded in flexure, but the general arrangement is on Austin lines, being a logical development of the A.40, with the cabin roof extended the full length of the body to give the appearance of a van. The car employs front wheel drive, using an arrangement which, until a few years ago, was virtually eschewed by British manufacturers, and it is therefore perhaps desirable to discuss first of all the handling characteristics that result from this more convenient construction.

Quantitative assessment of the steering and stability has not yet been performed by the makers, but we have been afforded the opportunity to handle the vehicle on dry, hard surfaces. The car has, naturally, a positive static margin, giving what the makers term "dart-like stability," and at the higher speeds large steering wheel movements are necessary to make corrections; the effort required is, however, very low. An oscillatory yaw-roll motion can be set up by disturbing the car at speed, but it is highly convergent and dies out rapidly.

The effect of a sudden steering input is to give a high rate of yaw with virtually no delay, the rate of yaw then dropping off as lateral acceleration forces develop. This classically stable response does not persist up to the limit of adhesion on dry surfaces, however: the unequal length front suspension arms give a "swing axle" effect, so that roll induces a favourable camber change on the outer front wheel and the desired safe "oversteer" condition appears. It should be added that the independent suspension results in the cars being very steady in any achievable turn on smooth surfaces, the need for rapid corrections being practically unknown. Steering the car by the throttle is very easy, and a banked turn can be negotiated without touching the steering-wheel.

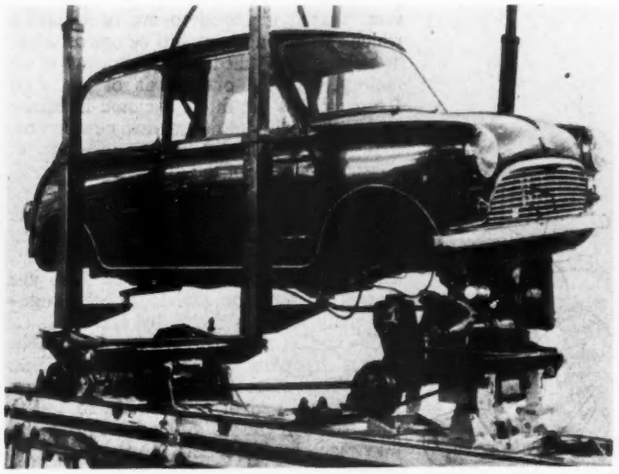
It is not possible to find the limit of cornering power in sustained tight turns, the car being power limited; an adhesion limit presumably takes effect at higher speeds or on wet surfaces. At low speeds the steering and engine can be abused very freely; the effect of increased power is to enlarge the radius of turn and even when the inside wheel is slipping intermittently the attitude of the car does not change. As speed is decreased a tight turn tightens up and the tail will finally swing out: with no power on the car loses speed very rapidly on a dry surface. One interesting characteristic noticeable in tight turns is the marked non-linearity of the steering effort. The self-centring force, which comes largely from "king pin" inclination, is high for small deflections, but low in sustained tight turns, with the result that if the wheel is released during a tight turn the car tends quite slowly to a gentle turn and then straightens up suddenly.

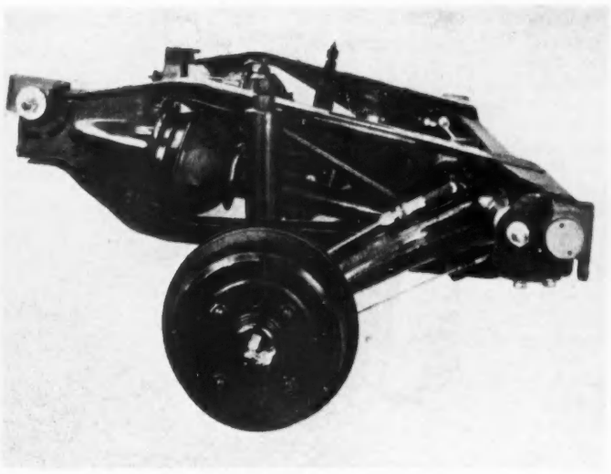
The suspension is hard, as expected on lightweight vehicles, allowing perceptible roll but very little pitch, both highly damped. The brakes, on a preproduction vehicle, were progressive and did not require great effort to make isolated stops; no attempt was made to elicit fade. The clutch is light, but not so light as to be out of harmony with the throttle. The most difficult control is the gear change; this has a small travel, but its positions are defined only at the far end of the remote control, so that it is not easy to be sure where in its imaginary gate it is. Because of the increased inertia on the input end of the gearbox, even those gears which have synchro-mesh are liable to crash in. In direct drive the vehicle is notably overgeared, and the reduction gears cover all but the top 10 m.p.h. on a scale of speed; however, at high engine speeds there is a good deal of noise, which, in new cars, was not at all objectionable in character.

In assessing the performance and handling qualities, it is important to bear in mind that the car is essentially a minimum-cost design, and any shortcomings should not therefore be regarded as inseparable from the use of those features, such as rubber suspension, that are distinctive. In fact, the handling qualities are so good as to shed no light at all on the question why Hotchkiss drive is highly favoured by the designers, particularly in such vehicles as the "Omnivan," where the ratio of unsprung to sprung mass becomes extreme when unladen. The British Motor Corporation draws attention to the fact that a rear drive vehicle is not superior in hill climbing ability if the larger part of the weight is carried on the front wheels: the new cars are claimed to climb a 1 in 3 gradient on a good surface, and have been demonstrated to stop and restart at half load on a 1 in 4 dry concrete test hill. The application of front wheel drive is expected to be limited by the effect of tractive effort on the handling qualities: it is, of course, accepted that high-powered front-wheel-drive cars need rigid-breaker tyres.

The car consists of a body in one piece, apart from bumpers and so on, to which two major sub-assemblies, the front and rear sub-frames, are attached. The provision of sub-frames is a necessary result of the system of suspension adopted, the short travel of the springs evoking loads in the suspension pivots and spring abutments too high to be absorbed in the shell. The use of sub-frames, which are themselves completely assembled before they meet the body, renders the assembly of the car particularly rapid, the only major jobs after the body is lowered on to the sub-frames being to secure the sub-frames and attach the shock-absorbers and steering links. The distinctive feature of the body is that it is designed to need little interior trim, and hence the joints in the panels constituting the cabin are on the outside, taking the form of the deep flanges that characterise the car. This results in the roof being completely surrounded by a gutter, but holes are drilled through it at the rear corners to let water escape. The door and boot hinges are on the outside, as on current B.M.C. designs, and the door catches are actuated by catenaries running to the leading edge of the door in the way associated with the Austin "Seven." Similarly following Austin practice, the rear windows are hinged along the leading edge on the de luxe version, while each front window has two sliding panes with spring-loaded plungers running along perforated tracks at the top of the door; because of the heavy rake of the screen pillar, only a relatively small opening is available. "Minor" instruments are used, but the starter switch is on the floor in the manner of a "Seven." Unusual features are large buckets on the inside of each door and at each end of the back seat, in which small items can be stowed; those on the doors are specially protected where they are kicked during entry and egress. The driver's seat, and the front passenger's on the de luxe car, adjust along inclined rails. The boot lid opens downward against two non-adjustable steel traces; within it are the petrol tank, battery and spare wheel, on top of which there is room for a number of cases or bags of different sizes. The fuel is transferred to the engine by an S.U. pump which is located

An Austin "Seven" in de luxe form with hinged rear windows and plastic capping strip on the exterior welds





(Left) An Austin "Seven" being assembled. The very large spring forces are contained within the sub-frame at the rear, while the dampers are attached to the body. The exhaust pipe is rigidly attached to the engine and a resilient mounting far back helps restrain the power unit on its flexible mountings. (Right) The rear sub-frame : the trailing arms pivot on plain bearings lubricated by nipples on the pivot pins. The hand-brake cables run over curved guides close to the axis of the suspension

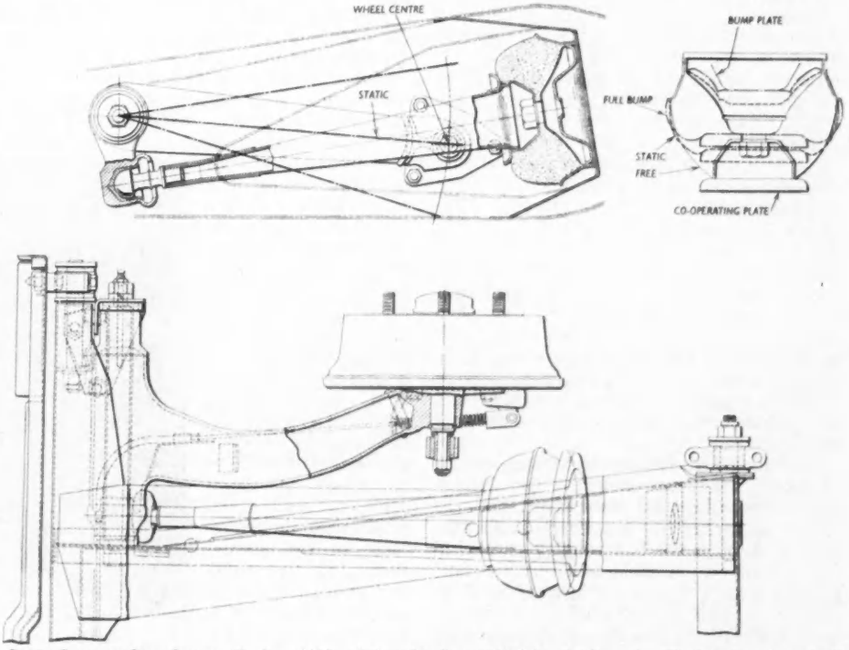
below the tank, thus ensuring that its vapour-handling qualities are adequate, although this does mean that the tank must be drained to remove the pump for cleaning the screen or any other attention : stoppages should be infrequent, since even the Austin uses an S.U. carburettor, and fine filtration is not needed. Hose clips rather than threaded unions are used extensively.

The torsional stiffness of the shell is quoted as 6500 lb ft per degree over the wheelbase.

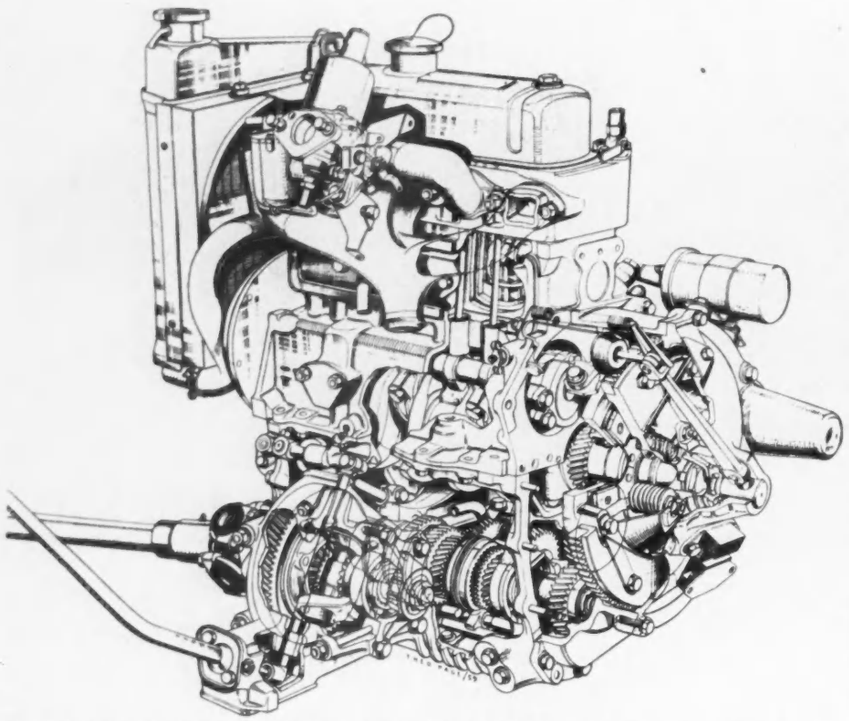
The rear sub-frame is seen in one of the accompanying photographs, and the details of the suspension in one of the drawings. A simple trailing arm geometry is used, the pivots being coaxial to give a roll centre at ground level, and the closing up of the suspension under braking torque appears to suppress very largely the phenomenon of diving under braking. The trailing arm suspension shows up strongly when the handbrake is used on an up gradient: the tail of the car rises sharply as the load comes on the rear wheels, and a short skid may occur. The arms are hollow and welded up from pressings ; the stub axles project through the rear ends to pick up the dampers. The pivots have to absorb not only the spring reactions but also the cornering forces, and hence two widely separated bearings are used ; the bushes are provided with oil at 1000-mile intervals through a nipple at the end of the pivot, the nipple being concealed by a rubber plug in a metal fillet, which is itself held on by one screw. The hubs are packed with grease, and it is hoped in the future to develop a lithium-based lubricant which will have an indefinite life. The hand-brake operates on the rear wheels by means of cables, which in order to be unaffected by suspension movements have to follow a somewhat tortuous path passing close to and parallel with the suspension axis ; the cables turn corners running over guides, and are there treated with graphite grease. No compensation is provided, and the adjustments are immediately accessible at the end of the brake lever. The hydraulic pressure to the rear brakes is restricted by an automatic pressure limiter to that reached at $0{\cdot}4g$ with a 60/40 distribution of effort ; further increases in system pressure reach only the front cylinders. Because of the low polar moments of wheels and tyres, brake locking is, of course, particularly to be guarded against, and the 7in leading-and-trailing drums call for a 75 lb effort to reach $0{\cdot}72g$.

The trailing arms bear on the spring units with a leverage of 5 : 1 referred to the wheels. The springs, which were developed by Moulton Developments, Ltd., an associate company of the British Motor Corporation, and are made by the Dunlop Rubber Company, comprise rubber solids of revolution stressed in compression and shear ; the change in cross section with stroke can be seen in the drawing of the rear suspension. The adoption of rubber springs was mainly in order to obtain a progressive characteristic, the wheel movements for a given frequency becoming more and more difficult to accommodate as the size of the car is reduced, but, as would be expected a significant degree of damping is also obtained; however, we are assured that these springs form the cheapest suspension medium available for such a vehicle. The bulk modulus of the spring medium is controlled within ± 5 per cent, and every unit is quantitatively tested, the deflection under load being held within ± 3 per cent : this measurement has to be made twenty-eight to thirty-two seconds after application of the load. Units passing this test then have the metal flange of the outer cup machined to bring the overall length within $\pm 0{\cdot}005$in. Telescopic dampers are also fitted, but the settings are so light that blow-off valves are not included in the design. The dampers are mounted on rubber bushes and the spring units have ball end fittings with nylon sockets, so that no periodic attentions are necessary : however, the unbonded damper mountings were not immune from failure on a small fleet of demonstration cars. The designed suspension frequency is 100 c.p.m.

The great preponderance of the working parts are concentrated on the front sub-frame. The power unit is basically a B.M.C. "A" series engine, but with a new crankshaft giving a stroke of 2·687in instead of the 3in of the A.30, A.35 and current A.40 engines : the bore/stroke ratio has risen to 0·92. The swept volume is 848c.c. and the compression ratio 8·3 ; at 5500 r.p.m. an output of 37 h.p. gross and 34 h.p. net is catalogued, while the maximum torque of 44 lb-ft (128 lb per square inch b.m.e.p.) is obtained at 2900 r.p.m. The engine is composed principally of iron castings, in



Levered suspension of rear wheel : additional damping is provided by a telescopic unit fitted to the spindle



The engine uses the transmission casing as its sump. The gear clusters are common to existing cars, but a novel remote control is incorporated

contrast to the magnesium alloy transmission casing that acts as its sump.

It will be recalled that B.M.C. engines have the gas passages passing in between the push-rods, and the distributor low down on the side remote from the camshaft. In order to render the sparking plugs and dip-stick accessible from the front, the engine has been installed back to front by normal standards, with the timing end at the left and the drive end at the right. Running the engine backwards calls for an idler gear between the direct-top gear cluster and the crankshaft, and this gear can just be distinguished in the " ghosted " drawing of the power unit. The primary " reduction " has a ratio of 1 : 1, in order to allow the existing gear cluster to be used. The clutch is fitted on the end of the crankshaft and is contained within an aluminium casing ; it has regained much of the accessibility expected with separate engines and gearboxes, but because the gear wheels are inside the main casing the clutch proper is within the flywheel. The presser plate carries three pillars which project through windows in the flywheel, and the drive is carried to these pillars by straps from the outer face of the flywheel. The clutch is closed by a set of coil springs in the usual way, and opened by a very simple withdrawal mechanism through a small ball race. The bushes in which the quill runs on the crankshaft are lubricated through a radial hole opening between two of the teeth in the gear, so that oil trapped between the teeth is forced inward. The oil must be kept from the clutch, and there are seals around the quill in both the flywheel and the crankcase.

The distinctive feature of the gearbox is, of course, the remote control. The selector shafts run below the main shaft, and the striker is carried on the short shaft seen passing through the box roughly parallel to the gear lever. A male arm on this shaft engages with a female on another shaft at right angles to it, so that axial and rotational movements of the one are transformed into rotational and axial movements of the other : this latter shaft is outside the gearbox proper, with the result that at its head there are two grease nipples, one of which can just be seen in our photograph of the front subframe. To prevent these shafts rattling when the ball and socket joint becomes slack, there is a piston in the socket spring-loaded against the ball. Another socket-ended arm at the bottom of this shaft engages with a normal gear lever : it will be realised that the striking motion corresponds to rotation of the inner shaft, to translation of the outer shaft, and, therefore, to up-and-down motion of the lever, so that the sense of the change is as usual on a vehicle with direct control of a gearbox in front of the driver.

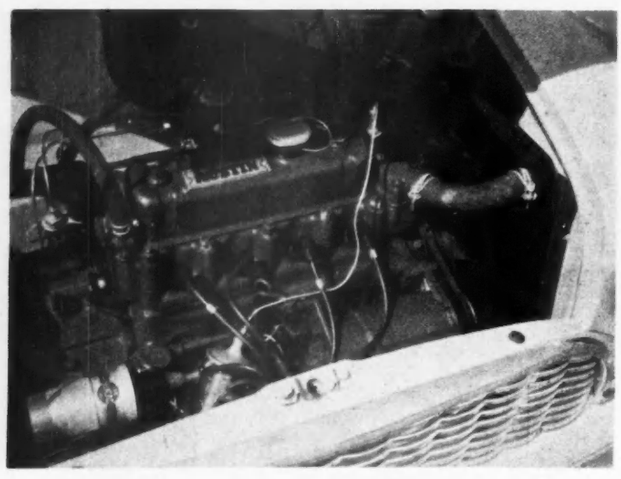
At the output end of the mainshaft there is a helical spur final drive with a ratio of 3·76 (64 : 17), while an extension slotted into the shaft leads to a right-angle drive for the speedometer cable.

Before studying the remainder of the transmission it is as well to consider the suspension geometry. Each wheel bearing carrier is mounted in ball joints at the ends of two transverse swing arms : in the " Minor " manner, the lower arm is braced by a rubber-mounted tie rod. These arms do not define parallelograms, being so arranged that the roll centre at the front is 2½in above ground level. Consequently, the length of the drive shafts from the differential to the hubs (different each side) varies with the movement of the suspension, and the usual splined joint with lubricant nipple (1000-mile intervals) is provided : we are advised that it is hoped to evolve a shaft in which this sliding joint will be enclosed with a bellows and filled with lubricant in the factory. At the outer ends of the shafts Rzeppa joints are fitted, enclosed in bellows and packed with lubricant when new, in order that steering deflections shall not upset the constant velocity of the drive. However, the use of constant velocity joints at one end means that the irregularity generated by the suspension deflection at the inner Hooke's joint is not cancelled out, and consequently a resilient joint is required here. This joint is another Moulton Developments design—the shaft itself is made by Hardy Spicer, Ltd.—and employs hollow conical rubber bushes in place of needle roller bearings. The outer surface of the rubber is bonded to a pair of metal shells, so that the rubber is compressed as the joint is clamped into place by its U-bolt. An angularity of 15 deg. (half-angle) is acceptable to these joints, which not only avoid an uncertain lubrication task, but also render dismantling of the joint far less exacting than with conventional couplings.

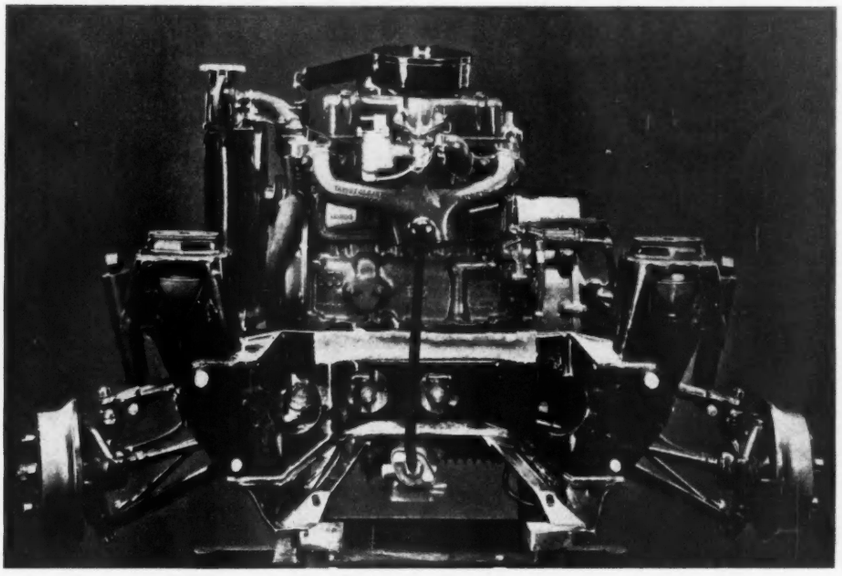
The inner ends of the lower swing arms also have rubber bushes : the inner pivots of the upper arms support the greater part of the spring reactions, and so grease-lubricated needle roller bearings are used here. The ball joints also are lubricated at 1000-mile intervals.

The power unit is carried on the sub-frame on rubber mountings, one near the foot of the gear lever and one at each side. Torque reactions are taken by two stays, one of which, visible in our illustration, is a rubber-bushed tie rod running backwards from the drive end of the cylinder block. The other is the exhaust pipe, which is attached rigidly to the manifold, clamped to the gearbox near the rear mounting cushion, and then attached to the body by a resilient rubber mounting farther aft.

The fan is belt driven from the timing end of the crankshaft in the customary way, but is on the upstream side of the radiator. It is closely cowled, and a notch in the cowling must be exploited to pass the fan belt round the blade tips when changing a belt. The remainder of the auxiliaries are much as on the existing cars, and the restricted opening of the bonnet (enforced by the deep curvature of the windscreen) makes them appear inaccessible, which is expected with a far-from-vertical distributor : however, we understand that the servicing problem has been considered, and that, for instance, the oil filter can readily be removed from beneath the vehicle.



The bonnet hinges backwards, and the air intake grille is fixed



The front sub-frame complete with suspension and power unit. The engine is a stroked "A" series unit with the cast magnesium gearbox acting as its sump. The inner pivots of the upper suspension arms are needle roller bearings, grease-gun lubricated: there are nipples also on the upper and lower ball joints, the drive shaft sliding joints and (just visible near the blanked-off face for a fuel pump) the remote control gear change

An interesting, if not significant, finding is that the power unit, complete with ancillaries such as radiator, but without fluids, weighs, at 310 lb, the same as the bare body shell. The complete car, with 2 gallons of fuel, but no payload, weighs 1260 lb, of which 60 per cent rests on the front wheels. All tyres are 5·20×10, the pressures being 24 lb (front) and 22 lb (rear) per square inch: such small tyres are unusual on a car of this power, and no figures for life are available, but changing round the wheels is recommended at 2000 mile intervals.

The maker's performance figures are given in the table:

Speed, m.p.h.	30	40	50	60
Time from rest, seconds	7·6	12·6	18·1	29
Fuel utilisation, m.p.g.	66	60	52	44

Maximum speed: 73·1 m.p.h. (corresponds to 4900 r.p.m.).
Fuel utilisation at full speed: 32·7 m.p.g.

Production of the "Seven" and "Mini-Minor" takes place at the Austin works at Longbridge, Birmingham, the bodies being made at the nearby works of Fisher and Ludlow, where they pass through the Rotodip plant and are coated in primer. Output at present is 3000 cars a week, but the plant is designed to yield 200,000 a year. Those mechanical parts which are not bought in are made in a newly equipped machine shop planned for very high productivity: the tools are principally British, but equipment of German, Swiss and United States origin is to be seen. An interesting feature of the conveyor lines for both engine and body is that, instead of the lesser components meeting the assembly as it progresses, all the parts are collected together on a trolley and loaded on to the line at its start: with this system some degree of selective assembly can, if necessary, be included without undue difficulty. In fact, automatic checking equipment is included in some of the transfer lines to maintain control over working limits. The gearbox proper is run by itself and the noise level checked before it is mated with the engine, and then the complete power unit is run for about twenty minutes: perhaps 5 per cent of the engines are tested on a dynamometer. It is interesting to note that the bores in the cast iron block are fine bored and then rolled, not honed.

The spraying of the bodies is automatic, each car being finished in one colour all over, inside and out: the colours available are red, white and blue, the shades of each differing between the Austin and the Morris. Mating of body and subframes, illustrated earlier in our account, is automatic, and the bolting up of the subframes takes less than two minutes.

Annual General Meeting of the Iron and Steel Institute

The technical sessions of the Iron and Steel Institute's Annual General Meeting, which were held on May 6 and 7 (before the printers' strike) proved to be of high importance. The floor and the gallery of the Hoare Memorial Hall, in Church House, Westminster, were filled almost to capacity when Dr. T. P. Colclough, C.B.E., presented his truly masterly "Review of Recent Developments in Steel Making." He made it clear that the use of oxygen gas at supersonic speed is bringing about a revolution in steel making practices in many countries. By means of tables he gave the materials balance and also the heat balance of process after process, in the following order:

(1) The Acid Bessemer Process with its ingot yield of 87·1 per cent of the metallics charged.

(2) The Basic Bessemer Process with its yield of 87·3 per cent of the metallics charged.

(3) The Open Hearth Furnace Process, with low pig iron charge—cold metal and producer gas, yield of 91·6 per cent.

(4) The Open Hearth Furnace Process, with 65 per cent hot metal: 95·3 per cent of the metal charged; 90 per cent of the total metallics charged.

(5) The L.D. Process: 93·1 per cent of the metal charged; 89·1 per cent of the total metallics charged.

(6) The Open Hearth Furnace Process, with 65 per cent hot metal and oxygen lancing, should yield: 96·1 per cent of the metal charged; 89·8 per cent of the total metallics charged.

Hence, it seems that lessons learnt from the success of the Austrian "L.D." process of steel making with the use of oxygen gas may be applicable to existing steel works in many countries. In open hearth furnace, 65 per cent hot metal plants now in existence, there appeared to be available a 35 per cent reduction in fuel consumption and a 35 per cent increase in steel production. In the past there has always been an unwanted whirlwind of nitrogen pumped through the regenerators, furnace and chimney stacks. Now, replacing the atmospheric air with oxygen enriched air greatly reduces the heat losses in the chimney gases and in radiation, without a large expenditure of new capital.

The meeting then became, in effect, an international symposium on the use of oxygen in various aspects of iron and steel making. From the Austrian point of view, O. Cuscoleca presented a paper on "The L.D. Process." From France, B. Trentini, P. Vayssierre and M. Allard contributed a paper entitled "Comments on the O.L.P. Process." From Sweden, this year's Bessemer Medallist, Professor Count Bo Kalling, described "Further Experience with the Kaldo Process." J. M. Gaines' paper dealt with "Recent Developments in Oxygen Steelmaking in North America."

By no means the least valuable of this interesting series of papers was the account given by A. Jackson, who is the technical director of the Appleby-Frodingham Steel Company, of the practical use of oxygen in steel making in a modified tilting furnace in that company's works. The results which he detailed from the Ajax furnace show that the process gives increased output, decreased ingot cost and greater flexibility of steel making.

Bainite

During the afternoon of the first day, while the above discussion was in progress, three papers on "Bainite" were presented elsewhere in the same building. Engineers generally have some idea of what is meant by such metallographical terms as austenite, martensite, troostite, sorbite and ferrite, but few will know the meaning of Bainite. It has been defined as a decomposition product of martensite obtained by tempering fully hardened steel at about 200 deg.–350 deg. Cent., or by austempering at 500 deg.–360 deg. Cent. It is claimed that carbon steels with this microstructure possess enhanced ductility for a given strength and greater freedom from internal stresses. Two of these papers came from the Metallurgy Department of the University of Manchester and the third from the Industrial Metallurgy Department of the University of Birmingham. Those in charge of the heat treatment of steel should study them.

Hydrogen in Steel

On the second morning of the meeting there was a further simultaneous session, at which experiments on "Hydrogen in Steel" were reported. This matter is of concern to many users of steels, and it is essential that metallurgists learn how to determine hydrogen in steel, how it diffuses, and how it may be removed. The four papers presented will help to this end.

Sixty Years of Armoured Car Development.—On page 100 of our previous issue two illustrations were transposed. The Humber armoured car is depicted facing to the left and the Daimler facing to the right.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ECONOMY AND NOISE OF HELICOPTERS

SIR,—I am perplexed by your comments on the letter appearing in your August 21 issue under this heading. Does anyone outside the Noise Abatement Society imagine that the Postmaster General standardised the B.S.A. "Bantam" because it was the noisiest machine available? We have erected a society in which cheapness succeeds, in which Scott and Vincent wither, in which Norton and Veloce neglect their conquering camshafts for quickly-assembled push-rod engines that would have been scorned twenty-five years ago, in which the name "Sunbeam" denotes a machine bereft of its former fiercely individual excellence. If this progress continues, the consequences will be much more serious than a degree of discomfort near roads and railway lines and aerodrome runways.

W. S. GRIEVESON

Darlington.
August 24, 1959.

Book Reviews

Introduction to Advanced Dynamics. By S. W. MCCUSKY. Addison-Wesley Publishing Company, Incorporated, 10–15, Chitty Street, London, W.1. Price 8.50 dollars.

DR. MCCUSKY is Kerr Professor of Mathematics and Astronomy at the Case Institute of Technology. His book, a first edition, provides an excellent introduction to advanced classical dynamics, a subject at one time regarded as the exclusive sphere of the mathematical physicist. Due to the recent developments in high-speed rotating machinery, supersonic aircraft and rocket and satellite technology, it is becoming of increasing importance to scientists and engineers. Successful design and efficient performance of modern machines demands a fundamental analysis of many complex problems. The theories explaining the dynamical behaviour of the most recent developments in applied science are based on advanced concepts of theoretical mechanics which go far beyond the elementary introduction given to the science undergraduate. The present book bridges, successfully, the wide gap existing between the elementary and more advanced concepts. The level of mathematics used should present no great difficulties to the science graduate. A knowledge of differential equations, some advanced calculus and elementary vector algebra is all that is required. No use is made of matrix algebra in treating oscillations, which is an unfortunate omission. Many oscillation problems arising to-day require the use of numerical techniques, which are relatively straightforward in principle. Practical solution, however, is only possible by use of a digital computer. The matrix presentation of eigen value problems is one ideally suited to the programming of the digital machine.

The contents are briefly as follows. The opening chapter is a thorough résumé of the fundamental concepts of Newtonian dynamics presented in vector notation. Newton's laws are followed by the elementary notions of energy, impact and momentum as applied to a single particle. Particle systems and motion of a single particle in a moving reference plane are also considered. Hamilton's principle and Lagrange's equations form the subject of chapter 2. The principle of virtual work and D'Alembert's principle treated in vector form precede an introduction to variational principles. By use of Hamilton's principle, Lagrange's equations are deduced for conservative holonomic systems. The application of Lagrange's equations to non-conservative and certain kinds of non-holonomic systems is also discussed. The chapter closes with a brief introduction to relativistic dynamics. The topic of the third chapter is central force motion which finds special application in the motion of earth satellites and electrons in the betatron accelerator. Inverse square forces, from which a most important type of central force motion arises, are dealt with and the stability of a particle moving in a circular orbit is considered. The problem of particle scattering is analysed, being of importance in nuclear physics, since it enables the scattering cross section of a material to be determined. The virial theorem, used in connection with the kinetic theory of gases, forms the concluding topic. Chapter 4 deals with the dynamics of a rigid body. A consideration of the inertial properties of a body is followed by the deduction of Euler's equations of motion and a definition of Euler's angles. Several examples of rigid body motion are discussed, including the motion of a rocket, a spinning projectile and a top under gravity.

Oscillatory motion, which constitutes the subject of the fifth chapter, plays an important part in many physical problems. Making use of Lagrange's equations and generalised co-ordinates, equations of oscillatory motion of a "finite degree of freedom" conservative system are derived. Examples are given, in two degrees of freedom, of both statically and dynamically coupled systems. The orthogonality and normalising conditions, ideally illustrated by use of vectors, are defined algebraically. The reason for dropping vector notation at this stage, where its use would have been to advantage, is difficult to appreciate. The analysis of forced motion is greatly simplified by use of normal co-ordinates, since each mode of oscillation is, thereby, made independent of the others. The free and force motions of non-conservative systems, with viscous damping, are briefly discussed and the stability of an oscillating motion is also considered. The vibrating string is used as an example of the extension of the analysis of coupled lumped mass systems and normal co-ordinates to the continuously distributed mass system. In statistical mechanics and the study of non-linear oscillations the Hamiltonian equations of motion are of greater use than Lagrange's equations. The Hamiltonian formulation, which makes use of momenta as well as co-ordinates in the generalised sense, is discussed in chapter 6. When a system contains ignorable or cyclic co-ordinates the number of degrees of freedom are effectively reduced. One such method of simplification devised by Routh, which is particularly useful in treating problems of oscillatory motion, is explained. The Hamiltonian equations lead naturally to a consideration of phase space and a definition of Liouville's theorem. Phase plane analysis is applied to one-dimensional systems with non-linear restoring force when the motion is periodic and stability criteria for general types of periodic motion are established. The Hamilton-Jacobi equation, used in the study of quantum mechanics, forms the subject of the final chapter. By a suitable phase space transformation of the co-ordinate system, ignorable co-ordinates are the only ones to appear in the Hamiltonian. Solution of the Hamilton-Jacobi equation for the system provides an appropriate generating function with which to perform the transformation. Action and angle variables, used extensively in the study of periodic motion, are also introduced.

The manuscript is clearly written and specific examples are worked through, where necessary, to clarify the theories as they are discussed. The method of illustration by example is a practice to be thoroughly recommended, since nothing is more frustrating than attempting to follow abstract theoretical arguments without the aid of a "light" to guide the way. Further examples are given at the ends of the chapters for the reader to solve, although answers are not supplied, an omission which should be rectified in the second edition. Specific references are quoted in the form of footnotes throughout the text, and a short, but well-chosen, list of general references is quoted at the end. The indexing is good and some cross-indexing is provided.

The book, although of general scientific interest, is best recommended to two particular groups. First, post-graduate teachers and students in science and engineering, since it provides the foundation of a comprehensive course in advanced dynamics. Secondly, scientists concerned with dynamical studies of high-speed machines, projectiles, &c., who find their knowledge of mechanics inadequate for application to modern engineering and scientific developments.

Reading German for Scientists. By HANS EICHNER and HANS HEIN. Chapman and Hall, 37, Essex Street, London, W.C.2. Price 30s.

A WORKING knowledge of German with the ability to read scientific books and articles is essential for most scientists. The present book caters specifically for this class of student, stressing those aspects which are needed to master the written language, while attending less to other matters which are required more by people who wish to speak and write German. Throughout, grammar is introduced economically and with this point in mind. Simple reading and translating exercises illustrate the grammatical ideas. At the same time, a basic vocabulary is built up of some 1400 words, of which the authors claim about 900 are fundamental and sufficiently unrelated to English equivalents so as to require learning by heart. Extracts, mainly from chemistry and physics, are chosen from well-known textbooks and scientific journals and form the bulk of the reading material.

Operations Research for Industrial Management. By PROFESSOR Dr. D. N. CHORAFAS, P.E., Reinhold Publishing Corporation. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

THIS is an original book among a mass of books and papers on operational research or O.R. techniques, many of which are "scissors and paste." Before attempting to assess the value of *Operations Research for Industrial Management* it must be made clear that the title does not accurately describe the contents of the book. It might more correctly be "Operations Research approached through Games Theory and Other Essays."

The exact nature of operational research is still a subject for argument, but there does seem to be emerging a fairly general agreement that as far as industrial applications of the "works" type are concerned, statistical or probability thinking is at the back of most of the techniques in use, including what are now considered as the "elementary" methods of analysis of variance, correlation-regression, and developments such as queueing theory and the so-called "Monte Carlo" type of simulation. The more complex "director level" type of problem is considered to require newer techniques such as linear programming and other methods which are mathematical but not statistical. The approach of Professor Chorafas is entirely different, and while much of what he has to say is still in the realms of theory and unproved in practice, it makes stimulating reading.

The book opens gently with an admirable chapter on "Simulations and its Pitfalls." The author points out that O.R. always calls for the building of a mathematical model, but immediately stresses the dangers which beset the builder of the model, particularly the dangers of over-simplification and of making unchecked assumptions, "no assumptions should be made before its effects are clearly defined," and "a model when completed, should be checked with actual data in its ability to predict the past." These warnings are strengthened by cautionary tales of, presumably fictitious, O.R. investigations that went sadly wrong. After this quiet opening, however, we come suddenly to the theory of games and the general proposition that situations in industry often resemble those of a "game" or battle of tactics, and that this type of approach can be made and used with success. The explanation of the basic "two-person zero-sum" game, as developed by von Neumann and his successors is simple and lucid, as is the following section developing into decision theory.

Having introduced game theory, the author moves on into what may be an associated, but is in effect a different field. Operational gaming, "a horse of another colour," as one of the authors of an excellent operational game has said. The operational game is a comparatively recent invention, having been developed in the U.S.A. within the past five years. The best known operational games are those of the American Management Association and I.B.M. These "games" purport to imitate highly complex business situations mathematically, and they are in use on quite a large scale, not only in America, but now in Great Britain, mainly as training and to some extent testing methods for younger executives. The usual arrangement is to have teams of four or five who wrestle with the problems involved in, say, the manufacture and selling of a motor-car, with the troubles of competition, &c. Their results are evaluated by referees according to the formulæ provided. Professor Chorafas' section on operational gaming as applied to industry is extremely interesting, and it may well be that this is not only a training technique, but a possible tool for actual management.

The book next passes on to linear programming. Linear programming is a technique about which much has been written in the past ten years, but which has yet to prove very useful in industry. It is in effect the setting up of a series of linear equations with practical constraints, e.g. in a food mix, the value of protein must not be less than a given percentage, and an attempt to find the best, or more popularly "optimum" solution. Linear programming has been found very useful by the oil industry, by animal food manufacturers in determining the best yet most economical mix, and in transport problems. It is bedevilled by the difficulty of adapting a real situation to a linear programming model.

Sandwiched in the middle of the linear programming section are two chapters on what the author calls "Matrix Analysis for Production Scheduling and Investory Control." These are interesting, but not quite up to the standard of the rest of the book.

Professor Chorafas has had the courage and initiative to work out and express a multitude of new and interesting ideas. Not all will be successful in practice, but this is a book well worth reading.

Applied Mechanics. By J. A. CORMACK, B.Sc. (Glas), A.R.T.C. Chatto and Windus, Ltd., 40–42, William IV Street, London, W.C.2. Price 30s.

THIS text-book is intended for candidates for the Ordinary National Certificate and it succeeds in its aim of presenting the subject of applied mechanics in a manner directly useful to them. It explains the conventional principles simply and gives a large number of exercises that will test the student's grasp of basic essentials. That they do not call for much imagination is not, in the writer's view, a matter for criticism of a book of this character. Such examples might usefully be given as an "Advanced Appendix" to an elementary book such as this, but not in a way to discourage the unbrilliant student: he is a representative of the numerous class that does most of the world's work and there will always be a need for text-books, such as this, to assist him in making the most of his talents.

Forest Machinery. By E. R. HUGGARD and T. H. OWEN. A. and C. Black, Ltd., 4–6, Soho Square, London, W.1. Price 24s.

MECHANISATION of forestry operations has not progressed very rapidly until recent years. Now it is gaining momentum especially as forestry in this country is increasing in importance to the national economy. The authors of this book have set out not merely to describe the various machines that are now available for all aspects of forest work; they have dealt, in a way that is not too technical, with the operations which can effectively be undertaken by the machines. Forestry comprises a good deal more than tree planting and felling. The preparation of land for the establishment of a forest, including the construction of suitable roadways through it are equally important factors. These matters, together with a study of the economic considerations, are carefully treated. The book, which is well illustrated, will be valuable to those branches of the engineering industry which may be called upon to design and adapt machines for forestry work, and it will prove just as valuable to those who are required to operate such machines.

Richtlinien für die Aufbereitung von Kesselspeisewasser und Kühlwasser. Published by the Vereinigung der Grosskesselbesitzer e.V. Essen: Vulkan-Verlag Dr. W. Classen, Essen, Haus der Technik, Hollestrasse 1g. Price DM.46.

THE preparation of feed water is a major aspect in the operation of steam plant, and a field in which major developments have taken place within the last decade. This is borne out by the present fifth edition of the *Richtlinien*, published by the German Association of Owners of Large Boiler Plant. In order to keep the size of the volume reasonably small, in spite of a nearly fourfold increase in the subject matter, the rules for water analysis which made up nearly half the previous edition have now been omitted and will be reissued in a separate volume. The book falls into three main sections: process technology, operation of steam and water circuits, and rules for ordering and performance specifications.

Die Zahnformen der Zahnräder. By H. TRIER. Berlin - Göttingen - Heidelberg: Springer - Verlag, Berlin - Wilmersdorf, Heidelberger Platz 3. Price DM.3.60.

THE present booklet, No. 47 in the series "Werkstattbücher," sets out to give a concise yet complete account of the principles and design of gears. Now in its fifth revised edition, it discusses straight and spiral spur and bevel gears, and gears connecting skew shafts, including hyperboloid and worm gearing. Each case is fully treated from the point of view of kinematics, and problems arising in the design, manufacture and application. This monograph will be welcomed by students as well as designers and by all those whose work brings them into contact with gearing problems.

Books of Reference

Friction Charts for Air Flow in Straight Ducts and Pipes. R. H. Young and J. M. Gasiorek. Publication 2007 of Sturtevant Engineering Company, Ltd., Southern House, Cannon Street, London, E.C.4. Price 7s. 6d.—Folded within this booklet are seven charts and a table covering two main cases, circular ducts with roughnesses of 0·0005ft, and, for pipes described as "Medium" in B.S. 1387 : 1957, 0·00015ft. For the former case charts correcting for other roughnesses and temperatures different from 60 deg. Fah. are given. Further charts allow calculation for rectangular ducts.

Interavia ABC, World Directory of Aviation and Astronautics. Interavia, Geneva 11 : distributed in Great Britain by W. H. Smith and Son, Ltd. and Wymans, Ltd. Price 80s.—The seventh issue of the "Interavia ABC" has a new title, previous issues having been styled "Directory of World Aviation": it remains the official annual of A.I.C.M.A., l'Association Internationale des Constructeurs de Material Aeronautique. The volume has increased by some fifty pages to contain a further 1800 organisations : this edition is 60 per cent revised, and for the most part has been corrected up to March 1, 1959.

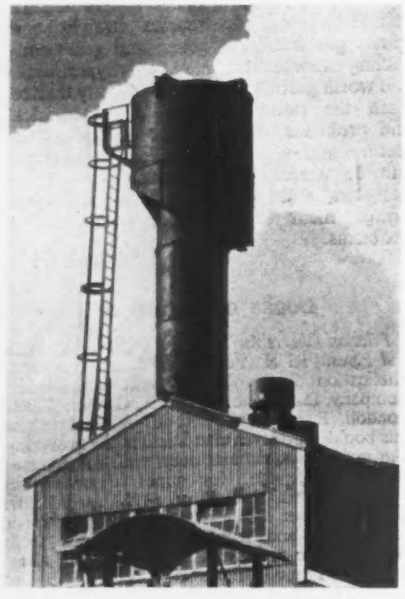
Mainly Metallurgy

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Research on Cast Iron and Its Manufacture

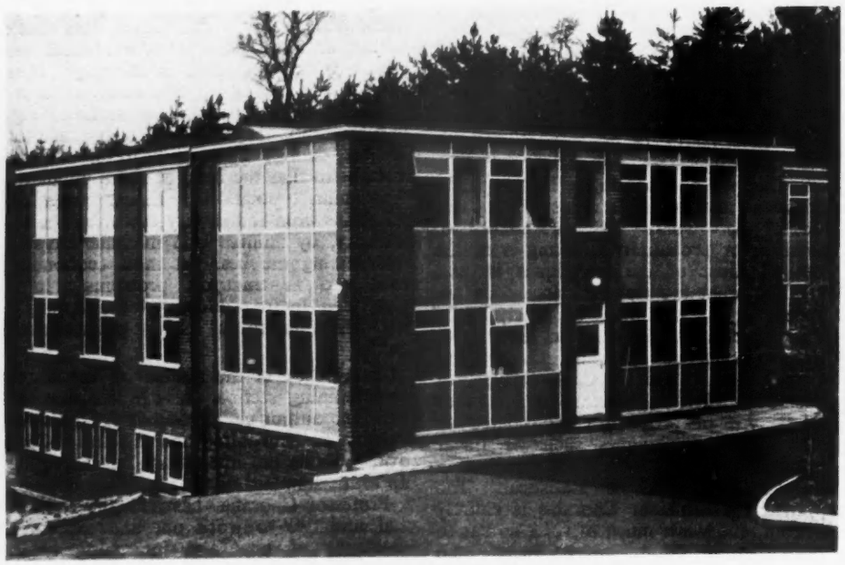
Cast iron was in wide use for cannons, railings, fireplaces, bridges, and even for the framework of the famous Crystal Palace over a century ago. Its virtues of being cast in the shapes required, being rigid and not too rapidly corroded still remain. But the intricacy of modern castings such as water-cooled or air-cooled cylinder blocks for internal combustion engines is greater, and the uniformity of the iron in the product has been so much improved as to be truly praiseworthy. According to the writing on a medal the researches of one man laid the foundation of scientific ironfounding in 1885. But nowadays any improvement, and notable ones appear every year, comes from the costly work of skilled teams of research workers. Each big section of the cast iron foundry business has built up its own laboratory staff to be expert in its speciality be that large pipes for water mains, domestic boilers, mowing machines, textile machinery, motor cylinders or any other of the manifold uses of cast iron.

In the early 1920's many firms subscribed to form the British Cast Iron Research Association, which at first had laboratories in the centre of Birmingham. In 1942 they were moved to Bordesley Hall, Alvechurch, near to the pleasant Lickey Hills and about ten miles south of the first laboratories. This



This new cupola in the experimental foundry was inaugurated in May

was a bold move in those days and it has now resulted in a centre of research on cast iron which is a credit to the industry and furthermore a source of welcome national prestige. This country has no monopoly of leadership in the foundry so it is good to find that the work of the B.C.I.R.A. is highly valued abroad and that a few years ago a former director was honoured by Aachen University.



"Foundry atmospheres" building at Bordesley Hall

Two important additions have been completed this summer, a new foundry atmospheres building and a new cupola in the experimental foundry, which are illustrated herewith.

Foundry Atmospheres

It was appropriate that Dr. J. G. Pearce should open the new foundry atmospheres laboratory because Great Britain has recently been leading the world in clear air legislation, and this new laboratory is probably unique. It must be especially welcome to all working foundrymen, who must never be allowed to regard themselves as the Cinderellas of all engineering works. Their castings are valuable and often essential to mankind and since the so-called Garrett report was issued in 1947 we have know what were to be regarded as desirable working conditions inside the foundry. The Clean Air Act, which became operative in 1958, covers external atmospheric pollution due to foundries. British public opinion is undoubtedly behind this legislation and the B.C.I.R.A. were early in the field in recognising this for the association formed its Foundry Atmospheres Committee in 1950.

Much success has already been achieved in trapping foundry dusts at source. Wherever possible down-draught is to be preferred for the dust is generally made below the operator's breathing zone. Where the dust is in a stream of rising hot air, as in mould sand knock out, up-draught ventilation may be preferable. The most difficult problems of foundry ventilation remain in the jobbing shop floor moulding. In the years 1951 and 1955 the B.C.I.R.A. sponsored conferences to put this matter over to the whole of the foundry industry, and the report of the latter is the most comprehensive record of work on foundry atmospheres in any language. Its team of experts has already helped not only the foundry industry but also the Government authorities in the public enquiries which have been held into the best methods of implementing the Clean Air Act in and about foundries.

Cupola with Scientific Control

Cupola furnaces are now used to melt most of the cast iron made in Great Britain and they will continue to be so used for many years to come. Hence the B.C.I.R.A. foresaw the need for installing at the Alvechurch laboratories an experimental cupola station which will serve the needs of the industry for fully instrumented operation, in order to test systematically and really scientifically all kinds of variables in cupola operation practice. This can not be done in any normal foundry where day-to-day output demands must always be paramount. The new cupola is of 30-in. internal diameter and it can be operated with the old-fashioned cold blast, or with the hot blast system which is now becoming the rule for the larger foundries. This versatility is coupled with the ability to run with or without water cooling, and with acid, basic or neutral slags. As may be seen from the illustration the cupola is fitted with a wet grit arrestor designed by the B.C.I.R.A.; it is also provided with mechanical charging gear, and a pig-casting machine has been added to help to dispose of the molten metal during experiments.

I.C.E. Conditions of Contract.—A recent survey undertaken by the Federation of Civil Engineering Contractors states that over 70 per cent of Britain's local authorities use the I.C.E. conditions of contract for letting their civil engineering contracts. Since the fourth edition of these conditions was issued in 1955, the number of local authorities using them has grown from 871 (50 per cent) in 1955 to 1197 (70 per cent) in 1959. Some sixty local authorities have adopted the I.C.E. Conditions of Contract in the past twelve months, and the Dock and Harbour Authorities' Association has recommended its members to use them.

Test Blocks for Indentation Hardness Testing*

By Mrs. J. G. WOOD, B.Sc. (Eng.)

The methods adopted at the N.P.L. for the production of standard hardness test blocks, in the range 200 HV to 950 HV, for the Vickers and Rockwell indentation hardness tests are described. Typical results from examination of the finished blocks demonstrate the excellent and consistent uniformity of hardness achieved.

STANDARD hardness test blocks provide the simplest and, under proper control, probably the most accurate means of verifying hardness testing machines. Such blocks, calibrated by the manufacturers or one of the standardising authorities, are commercially available for the three principal types of indentation hardness measurement, i.e. Vickers, Rockwell and Brinell, and for the full range of hardness required in industry. The standard test blocks provide the means for transferring to industry the standard of hardness maintained by the manufacturer or the standardising authority, and it will be evident that (*a*) the standard is essentially vested in the machine used for their calibration and (*b*) the accuracy with which the standard is transferred through the medium of the test block will be very much governed by the uniformity of hardness of the block, since the calibration must be based on a "sample test" of five or at most ten indentations for economic reasons.

In recent years, a close study has been made at the National Physical Laboratory of the problems associated with the establishment and maintenance of high-grade standards for the Vickers (HV) and Rockwell (HRC and HRB) scales of hardness. A new deadweight machine for the HV scale, employing loads of 30, 50, 100 and 120 kgf and exploiting new principles of load control during the indenting process, has been constructed[1] and a new deadweight machine for the HRC and HRB scales is at present being built. A critical examination of the performance of the deadweight Vickers machine has been made. The use of statistical techniques permitted separate evaluation of the effect of most of the factors which influence the measurement of hardness by such a machine, but it was not possible to separate test-block variability, i.e. variability due to non-uniformity of hardness of the block, from machine variability, i.e. variability due to random errors in the indenting procedure. To establish the precision of the machine itself it was therefore essential to use test blocks of the highest attainable uniformity of hardness. None of the commercial sources of blocks—and they were sought throughout the world—consistently provided the requisite degree of uniformity, and it was thus necessary to investigate at the Laboratory the possibility of making the more uniform blocks needed. The techniques developed provided standard test blocks covering the range 200 HV to 950 HV which were uniform within 10 HV at the upper end of the scale and within 4 HV at the lower end. Furthermore, all the blocks of a batch prepared at one time showed the same degree of uniformity and had closely the same hardness, a point of considerable importance when an extended series of measurements involving some 200 or more indentations has to be made at any required hardness level. These blocks have enabled a full appraisal of the accuracy of the machine to be made. It has also been established that they are uniformly hard to sufficient depth for use in the Rockwell scale of measurement.

The availability of highly uniform standard hardness test blocks offers considerable advantages for the intercomparison of the standards of hardness maintained by manufacturers and standardising authorities throughout the world and thus contributes substantially to the realisation of a uniform standard of hardness. It also improves the accuracy with which the standard can be transferred to industry on the basis of a "sample test" of indentations. It is believed, therefore, that the techniques which have been evolved at the Laboratory will be of interest and value to those concerned with the calibration of hardness standards, and a description of the techniques is given in this paper.

Material

In initial experiments to obtain blocks harder than 900 HV a plain carbon steel (1·1 per cent carbon, 0·4 per cent manganese) was used. These blocks are designated *V* in subsequent tables of results. In later work, when the method of production had been finalised and softer blocks were required, an alloy steel (1·0 per cent carbon, 1·2 per cent manganese, 0·6 per cent chromium, 0·5 per cent nickel, 0·4 per cent tungsten, 0·2 per cent vanadium, 0·2 per cent silica, 0·01 per cent sulphur, 0·03 per cent phosphorus) known as "Staytoform" was used. Blocks from this steel are designated *F*. Both steels were supplied in 2½in by ½in bar, which was cut into 2½in lengths to form blocks 2·5in by 1·75in by 0·4in.

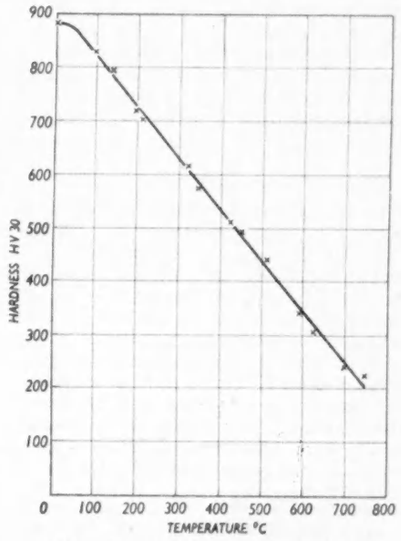
Preparation and Hardening

The top and bottom surfaces of the blocks were ground to ensure a clean run-off of the heating medium. File cuts were made in the edges at the corners, so as to leave the surfaces unbroken, and a supporting wire wrapped round the periphery leaving the surfaces unimpeded. The blocks were pre heated to 450 deg. Cent. and then immersed in a cyanide bath, containing 20 to 25 per cent sodium cyanide, for seven minutes. This period was found to be sufficient for the block to attain a uniform temperature without decarbonisation of the surfaces. The temperature of the bath was maintained at 760 deg. to 780 deg. Cent. for the plain carbon steel and at 800 deg. to 820 deg. Cent. for the alloy steel. It was found advisable to clean the bath before use with a regenerating salt to prevent stray matter adhering to the surfaces and thus reducing the effectiveness of the quench over local areas. The blocks were quenched individually in brine, composed of 1 lb sodium chloride to 1 gallon of tap water, at room temperature. Temperature changes of the quench of several degrees did not affect the uniformity of hardness, but quenching in water without salt, or in oil, always produced blocks with local soft areas.

Tempering

To relieve partially stresses induced by the quench, the hardened blocks were boiled in water for one hour with a resultant reduction in hardness of the order of 60 HV. To obtain lower levels of hardness, the blocks were heated in an electric oven at temperatures ranging from 100 deg. to 750 deg. Cent. The oven was rapidly raised to the required temperature, which was then maintained for three hours, after which it was allowed to cool slowly to room temperature.

The effect of the tempering temperature upon the hardness of the alloy steel is shown in Fig. 1, which reveals a closely linear relationship over a wide temperature range



Effect of tempering "Staytoform" steel

and a reduction of hardness of approximately 1 HV for a degree Centigrade rise in the tempering temperature. Blocks of this steel may therefore be produced at any desired hardness between 200 HV and 880 HV within close limits by a suitable choice of tempering temperature.

Mechanical Processing

The blocks were wet ground on a rotary surface grinder using a 38A60–G8VBE wheel, which was regularly redressed during the grinding operation and set to advance the cut automatically by 0·0001in at each traverse. The blocks were turned over frequently to compensate for up to 0·005in initial bend produced during hardening and to remove the distortion arising as stresses were relieved during grinding. As soon as both surfaces had cleaned up a further 0·004in was removed from the working surface in 0·0001in cuts and then 0·001in was removed by an automatic lapping process using "Norbide" 220 grit abrasive.

The surface was brought to a bright finish, with only fine abrasive scratches, by hand lapping with 2μm diamond dust on a cast iron lap. A final mirror finish, with a centre line average roughness value of less than 0·5μin was achieved by polishing on an 8in diameter wheel rotating at 400 r.p.m., the wheel being covered with thin rayon material moistened with ethylene glycol as lubricant and lightly impregnated with 1μm diamond dust.

Recent limited experiments have shown that a dull lapped finish with a centre line average

* Communication from the National Physical Laboratory.

value of 3μin can be obtained straight from grinding on a commercially available automatic lap using a fine abrasive in an oil base. This eliminates both lapping operations in the earlier procedure and is particularly useful for the soft blocks which are not amenable to hand lapping.

Tests for Uniformity

The uniformity of hardness of blocks heat-treated and machined by the methods described has been established in three ways :

(1) By indenting the blocks on the N.P.L. deadweight Vickers machine with a load of 30 kgf and measuring the diagonals of the indentations on a specially designed measuring microscope.

(2) By examining the metallurgical structure revealed by etching the polished surface of the block.

(3) By determining to what depth uniform hardness extends.

Results obtained by the first form of examination are tabulated in Tables I and II in terms of diamond pyramid hardness numbers and those obtained by the third in Table III.

Surface Hardness

A representative number of *F* blocks within the range 220 HV to 880 HV were examined by making sets of ten Vickers indentations randomly disposed over the surface of each block, though in a few cases during the initial work sets of only five indentations were made. The ranges of hardness observed in each set of indentations are given in Table I. They show that the hardening technique developed gives consistent results and the small range at the hard end of the scale, where most difficulty is experienced by industrial manufacturers, is particularly impressive :

Table I—*Uniformity of Blocks Ranging from 220 HV to 880 HV*

Identification No.	Vickers hardness, HV 30	Number of indentations in set	Observed range in set, HV units
F.34	879	10	11
F.13	877	10	9
F.11	876	10	9
F.4	869	5	2
F.14	823	10	7
F.15	823	10	6
F.16	819	10	7
F.3	796	10	7
F.5	795	5	2
F.7	794	5	12
F.8	787	10	9
F.10	786	5	4
F.12	781	10	12
F.20	712	10	7
F.22	711	10	7
F.21	706	10	7
F.1	697	10	4
F.26	610	10	7
F.2	570	5	3
F.30	508	10	6
F.9	485	10	4
F.42	429	10	8
F.33	335	10	7
F.46	302	10	5
F.50	239	10	4
F.52	220	10	3

Although these values were obtained for a small sample of, at most, ten indentations and, therefore, may not reveal the full variability of the hardness of a block, they do include additional variability due to small inherent errors in both the indenting machine and the measuring microscope.

A few *F* blocks which have been used extensively for experimental work provide a thorough examination of block variability. Many sets of ten indentations have been made on these blocks, and the minimum and maximum ranges observed, together with the average range, are tabulated for six blocks in Table II :

Table II—*Uniformity of Blocks Subjected to a Detailed Examination*

Identification number	Vickers hardness HV 30	Number of sets of ten indentations	Average range, HV units	Minimum range in a set, HV units	Maximum range in a set, HV units
F.34	879	16	8	4	12
F.13	877	16	9	4	13
F.11	876	7	9	2	16
F.1	697	6	5	2	10
F.9	485	14	5	3	8
F.52	220	10	2	1·5	3

As might be expected, the maximum ranges are larger than those displayed in Table I for a single set of ten indentations, but no appreciable lack of uniformity is revealed. In contrast with Table I, where the results are affected by the variability due to small sampling, the steadily decreasing average range shown in Table II confirms the generally accepted view that uniformity is improved by tempering.

The overall range of a *V* type block was revealed in an experiment in which nineteen sets of five indentations were made over the surface of the block, giving average, minimum and maximum ranges of 6, 2 and 11 HV respectively. These indentations were all made under the same conditions and the total range observed for this very hard block of 950 HV was only 14 HV.

Surface Structure

For a metallurgical examination of the hardened structure a particularly fine polish was obtained on the test surface, which was etched in a 2 per cent nital solution, i.e. two volumes nitric acid in ninety-eight volumes methyl alcohol, and then examined under a high-power microscope. It became evident that a block of uniform hardness showed only martensitic structure and that the presence of areas of troostite gave rise to inferior uniformity. This fact was demonstrated by the correlation between measurements of thirty-five indentations uniformly spaced over the surface of a *V* block and the structure surrounding each indentation, which was revealed by etching to a limited extent so that the troostite areas were appreciably affected whilst the martensite was only lightly attacked. The average hardness of the troostite areas was 924 HV, with a range from 902 HV to 939 HV, while the average hardness of the martensite areas was 943 HV, with a range from 940 HV to 949 HV. It should be noted that these ranges do not overlap and the results emphasise the importance of fully hardening the steel in order to obtain the uniformity conferred by martensitic structure. These distinct ranges also show the danger of applying statistical techniques to hardness values, which are unlikely to be normally distributed if more than one structure is present.

Depth of Hardness

The uniformity of hardness at different depths was obtained for a *V* block by indenting and etching at five levels through the block. The first level was the normal working surface, which is between 0·005in and 0·010in below the original surface, and further amounts of 0·003in, 0·005in, 0·010in and 0·010in were ground away in turn, the surface being lapped and polished at each stage. The average hardness measured and the range revealed by five indentations at each level are tabulated in Table III and show that the first appreciable decrease in hardness occurred at a depth of about 0·030in below the usual working surface. This surface was the first to reveal traces of troostite and was therefore considered to be the limiting depth for full hardening.

From the constitution of the alloy steel a greater depth of hardening may be expected from the *F* blocks, and it is therefore concluded that both types of blocks provide sufficient depth of uniform hardness for the Vickers and Rockwell tests envisaged at the Laboratory.

Table III—*Uniformity of Hardness at Levels Through a Block*

Depth (inches)	0·005	0·008	0·013	0·023	0·033
HV 30	931	932	926	927	910
Range (HV units)	10	12	7	8	14

Conclusions

The three most important factors affecting the heat-treatment process adopted are that the salt bath shall be free from sludge, that the temperature of the blocks shall be within the prescribed limits when quenched, and that the quench shall be rapid and uniform. The latter requirement was only fulfilled by the use of a brine bath. During mechanical processing the grinding conditions are particularly critical ; localised overheating of the surface by using a wheel of incorrect grit size or bonding or by using too heavy a cut at any stage of the surfacing may ruin an otherwise satisfactory block. It was for this reason that the removal of at least 0·001in of metal by mechanical lapping was introduced, since even the lightest grinding produces some local overheating.

Flatness of the lower surface of the block is more important than is sometimes realised. A rocking block will enlarge Vickers indentations, while a block which flexes under load will not permit true depth measurement in the Rockwell test. Attention must therefore be paid to the grinding of this surface.

A mirror finish, which is readily obtained with diamond dust polishing, even with soft blocks, is considered to be essential if precision is to be obtained from the Vickers test. The high reflectivity of the polished surface increases the contrast between the indentation and the surrounding surface of the block seen in the measuring microscope and, in addition, the corners of the indentations are not marred by scratches or grinding marks. The mirror finish also provides a surface suitable for etching and this technique provides a rapid means of revealing the presence of soft spots which is particularly useful during periods of experimental hardening or if there is doubt concerning the quality of a block.

Hardness test blocks are now made by the heat-treatment and finishing methods described with consistently successful results, and the uniform blocks so provided have enabled a critical appraisal to be made of both the standard deadweight machine and

the prototype measuring microscope which were built for the Vickers test at the N.P.L. In addition, they have enabled a critical examination to be made, in both Vickers and Rockwell tests, of the influence of small variations in the indenting cycle, and confirmed, what had been earlier suspected, that the cycle must be precisely defined.

ACKNOWLEDGMENTS

The author wishes to acknowledge the advice of Mr. H. Bull, of Brown Bayley Steels, Ltd., Sheffield, 10, who recommended the use of "Staytoform" steel, and the advice and assistance of Mr. R. S. Marriner throughout this work. The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

REFERENCE

1 "A New Standard Hardness Testing Machine," R. S. Marriner and F. C. P. Mason, *Metallurgia*, 1958, LVII, 47.

Blower for Low-Pressure Oil-Free Air

From a study of compression processes the British Internal Combustion Engine Research Association (B.I.C.E.R.A.) has developed a blade pattern blower based on an entirely new principle. The blower has been designed to obtain continuous inlet and delivery processes at constant velocity. Design considerations are noted and the results of tests in a prototype machine recorded.

THE B.I.C.E.R.A. blade-type blower is a machine working on a new principle evolved from a study of compression processes and the need for a better but not more expensive machine than the Roots type blower. When the new compression cycle was discovered it was developed in its elementary form so that in addition to being a prototype test machine it also bore a close resemblance to the possible future commercial machine built to a limited cost. A wide range of design variables exists and the machine described is not the only form in which the principle can be applied.

The object of the design was to obtain continuous inlet and delivery processes at constant velocity and an efficient compression process. In the interests of low cost and reliability it was thought necessary to break away from the normal two-rotor type of machine, which requires accurate phasing and an attendant expensive gear train.

OPERATING CYCLE

In this machine the intake, compression and delivery processes take place in an annular channel formed in a rotor and divided at two points (1) and (2), as shown in Fig. 1, the division (1) being a local

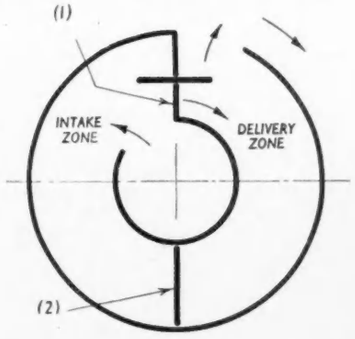


Fig. 1—Descriptive diagram of mode of operation

constriction of the channel and the other (2) a thin blade which can turn on its own stationary axis. When positioned across the channel, this blade forms a blockage so that the revolving of the constriction acts like a piston causing an increase in channel volume on the one side and a decrease on the other which give intake and delivery through ports in the walls of the channel. Before the revolving piston reaches the blade, the latter is turned through 90 deg. so that it is capable of passing through a narrow slot in the piston as it passes over the blade. A sequence of blades gives continuous seals both in the piston and as partitions dividing the channel, as shown in Fig. 2.

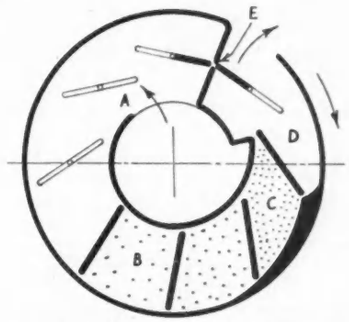


Fig. 2—Modified form giving internal compression

During rotation of the one blade relative to the next, the space between them varies, and this may be used to obtain internal compression. Fresh charge taken in at *A* is trapped as volume *B* and then, by keeping this space sealed by making the channel converge, the air can be compressed down to volume *C* before this becomes part of the delivery space *D*.

The design was modified, as shown in Fig. 3, to reduce the production costs, and

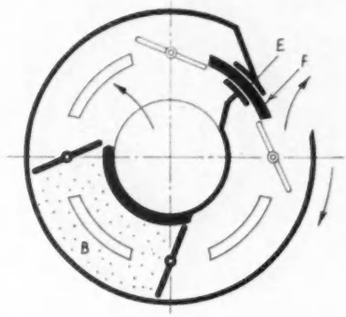


Fig. 3—Arrangement having alternate blades replaced by stationary spacing pieces

alternate blades have been replaced by stationary spacing pieces *F* which maintain the seal in slot *E*. Space *B* is large and so shaped that its volume does not change rapidly with blade tilt and so compression takes place by back flow. This is no great loss for low-pressure machines, as the back-flow compression takes place in the stationary enclosed space *B* and imposes no torque load on the working mechanism, whereas the back-flow compression in Roots type blowers heavily loads the approaching lobe.

MECHANICAL CONSTRUCTION

The blades turning in the same direction as the rotor and at half its speed always point to the centre of the slot *E* and thus feed themselves through the narrowest possible slot. The minimum width of slot is determined by the thickness of the blades at the hub, which has to be sufficiently strong to take the air loading without causing a deflection at the tip greater than the clearance permissible when the blade passes through the slot. On small machines the blades are over-hung from their supporting shafts, but on larger machines it is possible to insert bearings at the remote ends of the blades, thereby permitting a greater ratio of blade length to diameter to be used.

The blades are mounted on shafts which rotate in a back plate which also supports the blade spacing pieces as shown in Fig. 4. A gear train giving a 2 : 1 reduction in speed, as shown in Fig. 5, drives the blades and keeps them in phase with the rotor driven

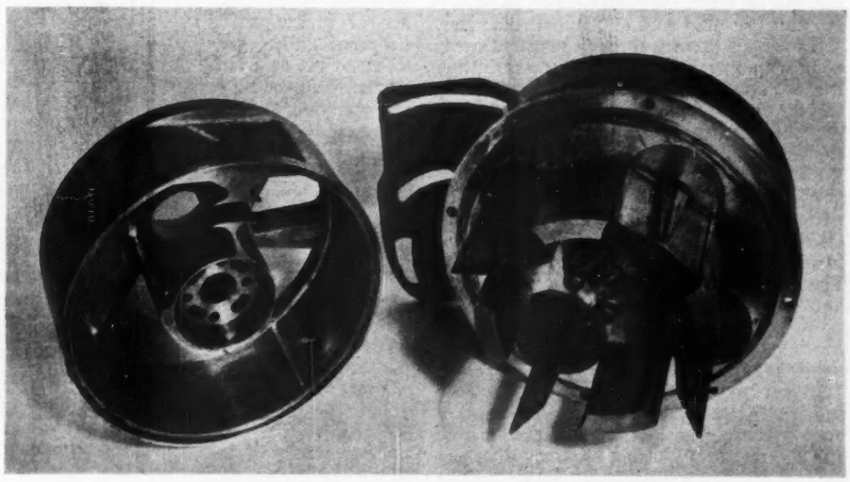


Fig. 4—Machine partly assembled showing blades, spacing pieces and inside of rotor

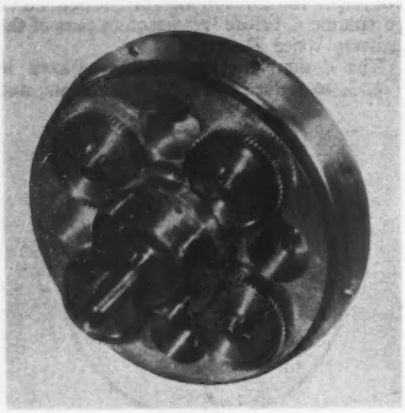


Fig. 5—Back of machine showing phasing gears

directly by the main shaft which transmits the power required for the compression process, leaving the blades free to rotate without doing work on the air.

Design Considerations

Air leakage is an important cause of loss of efficiency in rotary machines, and machining to fine clearances is a major source of expense. Therefore the fine clearance surfaces have been reduced to the simplest shapes and the clearances made independent of the accuracy of the phasing of the blades. The slot *E* spans the gaps between the spacers and the hubs of the blades. With these hubs having a diameter equal to the width of the slot in the rotor, the blades have a degree of freedom to rock on their own axes as the slot passes over them without the seal being broken or the tips fouling.

The seal made by the blades on the opposite side of the channel is also made between arcs of circles. The tips of the blades are radiused so that the blade has a degree of freedom to rock on its own axis without altering tip clearance. The only surfaces of the channel that need accurate machining are the slot *E* and the walls enclosing the space *B*.

Another source of loss is the air flow throttling losses. These largely determine the operating speed, which determines the size of machine and directly influences its efficiency, since raising the speed increases the throughput without increasing the leakage. It has been found possible to have ports approximately equal in area to the cross section of the channel at *B* so that the air speeds are comparable with the rotor velocity at the mean channel diameter. With the air passing through constant areas of port and channel, there is little throttling loss. In addition, the flow is assisted by taking the air into the centre of the rotor and passing it radially outward, as the centrifugal effect of the rotor tends to throw the air in this direction.

A third important loss is friction. The parts carrying out the compression process do not need lubrication, so the only friction losses are those of the bearings and gears. The single rotor runs on two ball bearings and its shaft transmits all the compression power. The four blades also run on ball bearings and, as they run at only one-half rotor speed, the frictional losses are low. The gear-train loading comprises only these bearing friction losses and so gives only a very small power loss. The light loading and the fact that phasing accuracy does not have to be of the first order means a light and relatively inexpensive gear train.

The approximate swept volume is given by the blade flat surface area minus its thickness area times the blade pitch circle circumference. However, a small allowance has to be made for the tilt of the blades on either side of the trapped volume.

The Prototype Test Machine

The specification of this machine was :

Swept volume, revolutions per cubic foot	0·0555
Maximum operating speed, r.p.m.	4500
Maximum delivery pressure, lb per square inch gauge	5
Blade size, in	3 by 2·5 diameter by 0·45
Pitch circle diameter, in	5·2575
Casing overall size, in	9·25 diameter by 8·65
Weight of test machine, lb	About 40

The cast aluminium alloy rotor was designed to be in dynamic balance and originally was overhung from the main shaft, but a better performance has been obtained by supporting it at its outer end in a large diameter ball race mounted in the delivery air casing. At the same time the blade design was also modified and Figs. 4 and 6 show these modifications and mounting brackets for fitting the blower to an engine.

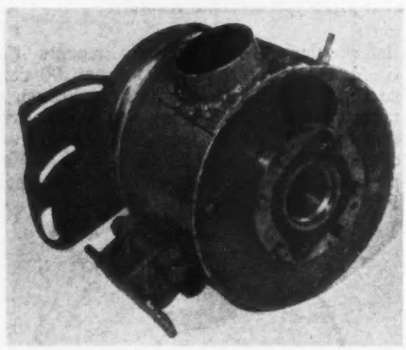


Fig. 6—Complete machine, showing brackets for engine mounting and blanked-off alternative port position

The blades, integral with their shafts, were machined from steel strip and the gear train consists of a steel pinion, bronze idlers and cast-iron blade gears. The steel pinion should be, but was not, hardened as in this case it was desired to accelerate gear wear to demonstrate the backlash of ±1 deg. on the main shaft could be accepted by the mechanism. The large gears dip into an oil bath for lubrication. The bearings closest to the air space are of grease-packed neoprene-sealed pattern and act as a barrier between the oil in the gear case and the air.

The experimental blower was designed as an engine pressure charger for relatively low pressures, the first target being 5 lb per square inch gauge at 4500 r.p.m. This gave a rotor having a rim velocity of 160ft per second and a mid-channel velocity of about 100ft per second. So the air velocities in the ports were of the order of 100ft per second, which is lower than that commonly occurring in the actual engine manifolds.

Performance tests were carried out up to the design condition of 5 lb per square inch gauge at 4500 r.p.m., and the results are shown in Fig. 7. The useful range of running conditions at 55 to 60 per cent efficiency compares favourably with that of any other comparable machine. The efficiencies based on air temperatures were higher than the overall figures as they profited by the heat losses during compression and delivery. At 3 lb per square inch gauge and more the temperature efficiency figures average seven units higher than the overall value.

After testing on an engine, it was found desirable to extend the working range to 5000 r.p.m. and 6 lb per square inch gauge delivery pressure to match an engine speed range of 3 : 1. To achieve this the rotor rim clearances were increased, and this reduced the efficiencies by about three units from those shown in Fig. 7. In this form the blower has been used for 65 hours of engine testing. Its use resulted in a 20 per cent increase in engine torque with little increase in the minimum fuel consumption.

The blower is quiet at low speeds and pressures, and only when engine speeds were above that which gave 4150 r.p.m. at the blower and 4·5 lb per square inch gauge pressure, did the blower noise noticeably exceed the engine noise. A simple inlet silencer reduced the noise below engine level up to the maximum speed of 2200 engine revolutions per minutes.

Applications

Whilst the experimental blower was made for low-pressure charging of a four-stroke cycle engine it is suitable for supplying the scavenge air for two-stroke cycle engines. The outer casing is, in effect, a built-in delivery capacity chamber which gives the advantages of damping out pressure fluctuations and permitting a wide choice of delivery duct positions.

The basic principle of this compression cycle can be used for any size of machine. However, as with all rotary blowers having clearances around the working parts, it would be expected that the efficiency would fall rapidly for sizes under 50 cubic feet per minute. Very small units could be made for pumping liquids, and it is thought that this principle could be used for an oil or fuel pump. The cycle gives steady flow

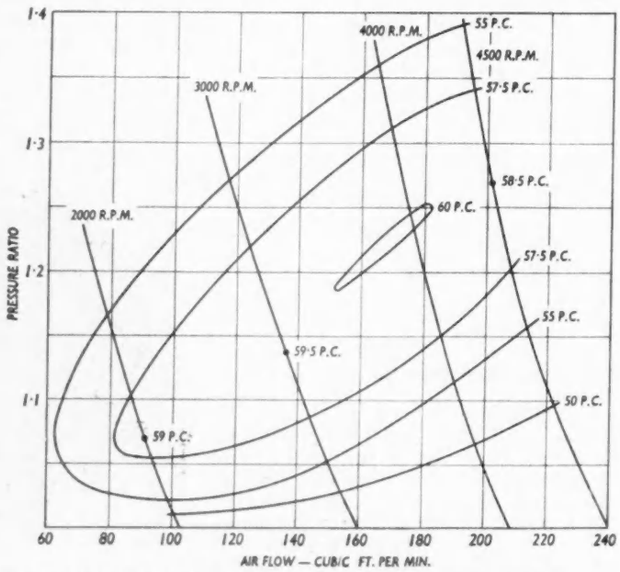


Fig. 7—Relationship between overall adiabatic efficiency, rotor speed, pressure ratio and air flow for outward-flow rotor with front bearing

free from fluid trapping, and the flow is assisted by a small centrifugal head.

For larger machines, over 500 cubic feet per minute, it may prove economic to use a more complicated mechanism in order to reduce the overall bulk per unit of swept volume and to assist fabricated construction methods. The machine would then be simpler to produce in small numbers than the Roots type or others which require complicated rotor and casing castings. This form of design would have a rotor giving two air cycles per revolution, as shown diagrammatically in Fig. 8, and leads to a

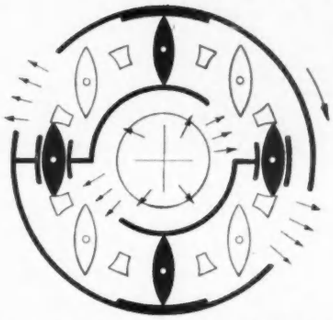


Fig. 8—Two-cycle rotor with spacing pieces

rotor which is in natural dynamic and pressure balance. A greater number of blades would be necessary, thicker in relation to their diameter, thus facilitating the fitting of bearings at their outer ends.

This article has been prepared from a report by D. W. Tryhorn, B.Sc.(Hons.) of The British Internal Combustion Research Association, Slough.

National Radio Show

DOMESTIC television receivers at the National Radio Show this year (open until September 5 at Earl's Court, London) are influenced in styling by the general use of wide-angle (110 deg.) tubes, resulting in reduced front-to-back dimensions, and a display of considerable ingenuity by the makers in inventing names to emphasise this characteristic. A less evident technical step has been the adoption of frame-grid, double-triode r.f. valves for higher sensitivity and reduced background. On the radio side, more manufacturers than ever are showing transistorised sets. A "Careers in Electronics" stand is again featured and includes a section devoted to telecommunications and microwave techniques. Pye Telecommunications, Ltd., presents recordings and films of the transmission of signals across the Atlantic using reflection from the moon. There is only scattered evidence of interest in home construction, which might provide a pool of future radio technicians, although the movement is large enough for one of the demonstration stands of Mullard, Ltd., to be devoted to it. Constructional kits for two oscilloscopes and a valve voltmeter are available from Cossor Instruments, Ltd., and are reported to be popular with small servicing organisations, where savings in the region of £7 to £11 compared with factory-assembled models justify the time occupied in building the apparatus. Radio kits are not in evidence among the large manufacturers' exhibits, although we heard the view expressed that transistors may revive interest in building at home by restoring the popularity of the battery receiver. The Post Office stand recalls the approaching jubilee (on September 29) of the G.P.O. coastal radio stations by exhibiting a typical control console with M.F. receiver and switch panels for remote selection of various v.h.f. facilities. The Royal Navy and Royal Air Force exhibits both illustrate the training given to entrants to the radio trades, and the R.A.F. also displays the new "Raftrac" analogue computer just completed at the Technical College, Henlow, for instructing R.A.F. technical officers in guided missile systems.

The Study of Mechanisms

By EWEN M'EWEN, M.Sc. (Eng.), M.I.Mech.E.

IT is commonly thought that mechanisms are just ingenious devices such as those in Jones' classic three-volume compendium, and that all that need be known about them is what is covered in a University second-year course on Theory of Machines with its velocity and acceleration diagrams. A minority of specialists, on the contrary, are concerned lest we fall too far behind other countries in this field, particularly Russia, Germany and the U.S.A., and would like to see a specialist University Department which would attract students and develop the study of mechanisms. The general industrial attitude is one of apathy, and a firm conviction that any intelligent draughtsman can do all that is wanted by trial and error. What, then, is really the case ?

Probably in 99 per cent of industrial mechanisms little if any advanced theory is applied ; most are "solved" by trial and error on the drawing board and in the development. Few designers have even heard of the synthesis of mechanisms and it has been observed that the more complex the mechanism the lower the standard of design.

Complex machines are usually mere assemblies of simple elements, and all too often there are glaring examples of neglect of first principles. There are notable exceptions where inventive ingenuity has intuitively grasped the overall solution and I do not believe that in this respect we are in any way behind other countries; nevertheless, in detail we often are, and it is notable that the graduate of a Technische Hochschule has a better overall grasp of problems than either our H.N.C. or graduate engineer. Our graduates are well trained in analysis, but have not the ability to see the whole picture and to create ; the H.N.C. man usually has more ability in this respect. He is more likely to produce a design, but it will require in most cases (other than trivial ones) considerable development.

In fact, the normal teaching of Theory of Machines is quite inadequate for problems of high-speed mechanisms and those requiring precision. It is based on rigid elements without manufacturing error or working clearances, does not cater for wear and generally does not adequately take into account inertia effects. In fact, any mechanism is made up of elements of a certain degree of elasticity, has manufacturing tolerances, and working clearances, is subject to wear—which means that friction and localised stresses require attention—and may have unexpected inertia effects. For a first simple example, the classic binder knotting mechanism sometimes, particularly in higher speed applications, fails to tie in use although perfect in slow motion : one cause is the inertia of the string. As a second, a certain "constant velocity" universal joint at full load and speed, had on test a velocity fluctuation of the output shaft, when driving a load of small inertia, as severe as a plain Hooke's joint of equal angularity, owing primarily to elasticity of the components and secondarily to the different effect of the combination of clearances and inertias at speed compared with that in slow motion.

There is an extensive literature on mechanisms, although little of it is British since the days of Willis, Kennedy and Bennett, but much of it is descriptive, trivial or of little practical value. Perhaps the major contributions in the present century are those of the German schools on synthesis and of the Russians who have made advances in error kinematics. These are little known, and less applied, in this country. The theory of envelopes and conjugate surfaces, which governs the design of gear-cutting machines and tools, is in the unfashionable country of three-dimensional geometry, now despised by mathematicians and considered too esoteric by engineers. The principal advances in this field have been made in the U.S.A., Germany and Switzerland.

The current status of mechanisms study in this country is, in short, where the Theory of Structures was a few years ago before the modern developments began to take account of plastic as well as elastic deformation and to consider the effects of load duration and repetition as well as intensity. Mechanism theory must take into account elastic deformation and vibration of the elements as well as error kinematics. What is the way to improve this situation ?

A research and teaching laboratory for Mechanisms could do valuable work for the Universities and for Industry. The standard must be high but it must remain practical. I have argued elsewhere that many pieces of research which would be of real value in design are not attempted because they are of too practical a nature to appeal to Ph.D. examiners, or, to overcome this, are so dressed and written up as never to be read or understood by the man who would use the results : the designer in industry. Such a laboratory should face this problem squarely at the start. It should not scorn to collect, translate, and codify what is already available in odd places or foreign languages. The original paper by Professor Smith on the now common acceleration and velocity diagram appeared in the Proceedings of the Royal Society Edinburgh : how many University Lecturers in Engineering, let alone men in industry read such journals ?

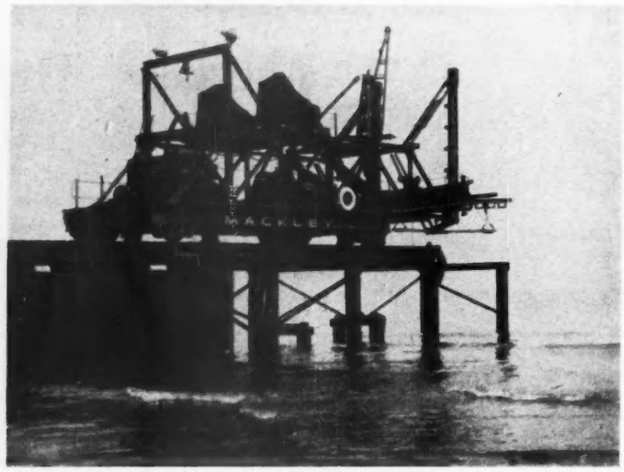
Finally, it should be remembered that watertight specialisation is a barrier to progress. The scope for fundamental work on mechanisms does not lie in paper exercises on highly simplified premises, but taking into account the properties of materials including lubricants, vibration theory, &c. Mechanism should be part of a University school of "Machine Design" including all these—and other—aspects. It would be essential to have real laboratory tests and here industry could supply existing material for study to mutual advantage, such as complete engines for study of the overall problems of valve gear (on which Arnold at Edinburgh has made a notable contribution), power circulating rigs for work on transmission components and so on.

It is encouraging to know that Imperial College is proposing some more intensive work on mechanisms : this note is intended to provide food for thought and to stimulate discussion of the problems which should not only assist Imperial College but encourage other University institutions to take a real interest in this field.

I would like to acknowledge the helpful discussions I have had with Dr. H. E. Merritt and several of my colleagues. The above views, however, are my own.

Offshore Piling Rig

A rail-mounted piling carriage, shown on the right, from which all the major operations in constructing a sewage outfall can be carried out, has been developed by J. T. Mackley and Co., Ltd., and used to build an outfall at Shoreham Harbour. The equipment mounted on the carriage is particularly comprehensive, a point of special interest being that two piles connected together to form a " trestle " can be driven simultaneously with the aid of air and water jets.

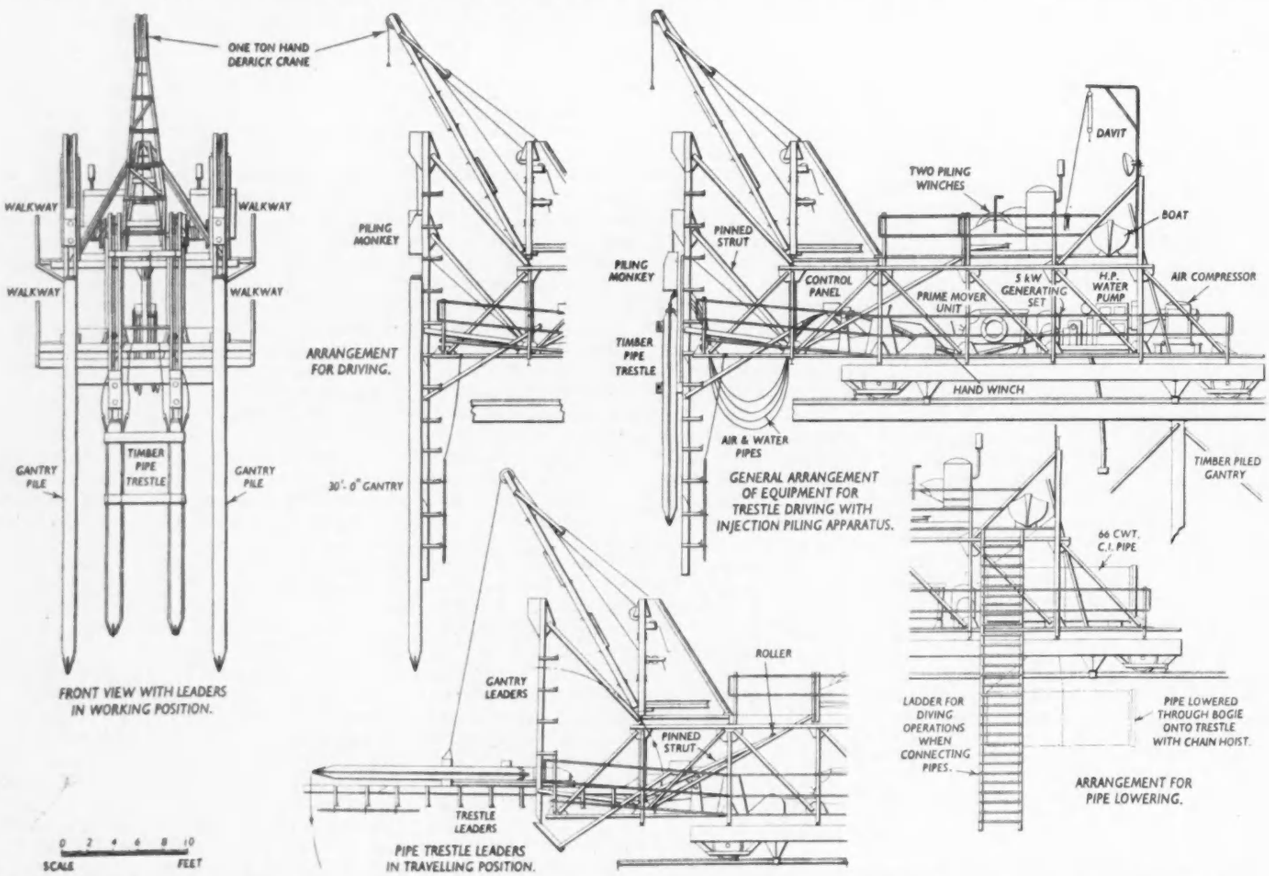


AN original machine has recently been used for the construction of a long outfall sewer at Shoreham Harbour. It consists of a large self-propelled carriage, running on rails with a gauge of 12ft and equipped with piling frames and other plant for the construction of (*a*) the gantry along which the machine itself travels, and (*b*) the sewer outfall which the gantry straddles. The machine has been dubbed " the monster " ; it has enabled quite high rates of progress to be reached in constructing the outfall, which extends out to sea for 1350ft at present. An extension of 300ft will begin this summer.

The outfall has been built for the Portslade and Southwick Outfall Sewerage Board, whose consulting engineers are Messrs. Lemon and Blizard. The contractor for this work, who was responsible for designing and developing " the monster," was J. T. Mackley and Co., Ltd.

The machine is well shown in the heading illustration and in the accompanying drawings. Its structure cantilevers 18ft ahead of the carriage, two fixed piling frames being carried at the end of the cantilever, one on each side ; the function of these frames is to drive the gantry piles. There are also two inner piling frames, for driving a pair of piles in the outfall " trestle," and these two frames are built together as a unit, which is hinged and can be " folded down " to the horizontal position as one of the sketches in the drawing shows. When the machine is in use, either the gantry piles or the trestle piles may be driven, but all four frames cannot be used at one time with the present deployment of winches. Thus there are at present two piling winches, each diesel-engine-driven, on the upper deck of the machine. Each frame has sliding leader extensions which can be lowered when the machine is in position. A 1-ton hand crane is mounted above the inner piling frames to lift the outfall trestles and for similar duties.

On the lower deck of the machine are : the prime mover, which apart from being the main motive power also drives a 5kW generator when the machine is stationary, thus giving lighting and power for tools ; a high-pressure water pump with a capacity of about 22,000 gallons per hour at 150 lb per square inch ; a compressor of 150 cubic feet capacity ; and a hand winch. Air and water leads are taken through a central control station. A welding set is also carried when necessary. The lower deck is built as an open well, and when pipe laying is to be done the compressor can be taken off the



Self-propelled piling rig. The rig is equipped to drive in the two gantry piles or a " trestle " of two outfall piles, or it can be used to place the sewer pipes

machine and a 12ft pipe slung between the decks, and handled by chain tackle at the upper deck level.

When fully loaded, the machine weighs about 48 tons. It is capable of a speed of 15 m.p.h. in an emergency, but its normal running speed is about 2 m.p.h. Several safety devices are incorporated on the undercarriage. If the machine is derailed the maximum drop on to the rail is ½in. Bolted to the underside of the undercarriage are some stiffened brackets with a wooden shoe which are clear of the rail by ½in. Should a wheel begin to derail a spring-loaded arm would touch the rail and, through a micro switch, give an audible warning to the driver. In the event of the safety limit being reached, a red light indicates, and shows, the wheel which is at fault. The machine is entirely self-supporting. It carries about 200 h.p. altogether.

The machine is being modified for the extension of the sewer by adding a further two piling frames, one on each side of the machine, for driving additional side raking piles for the gantry structure. The hand crane on the top of the structure is to be increased in size and mechanised with air winches, and hydraulic gear is to be fitted to the hinged piling frames.

Constructing the Outfall

As can be inferred from the foregoing description of the machine, the aim behind its design has been to reduce the constructional work at the exposed outer end of the outfall to several fairly standardised procedures, one or two of which can then be just fitted into one tide's work. Thus the machine is prepared and all the preliminaries are carried out on shore ; then, as soon as the tide is low enough, it travels out along the gantry and is in position ready to work at the earliest possible time. A further consideration has been the elimination, as far as possible, of operations which have to be done by divers, partly because of fluctuating sea-bed levels in this particular case. This was the governing consideration in attempting to drive a complete trestle, as described hereunder.

The first operation is driving the gantry piles. This is straightforward, as there is no limit to the headroom on the fixed outer frames, which are used for this operation. Two piles can thus be pitched on shore, and then driven independently, but at the same time when the machine has travelled out to the end of the gantry and the leaders have been lowered. The next " bay " of the gantry is then completed by fixing longitudinal and transverse steel beams between the pile tops, extending the rails on which the machine travels and adding a small catwalk.

For driving the piles of the outfall itself, a novel method has been adopted, and in this case it has been found more practical to mount the piles on the inner frames in a horizontal position, as shown in the lower view of the drawing. They are held in this position by the derrick, as the machine travels out and are then inserted at the appropriate point between gantry beams by gradually paying out the derrick rope as the machine " inches " forward.

The outfall consists of a series of trestles as shown by the typical trestle in the left-hand view. Each one consists simply of two cross members bolted to the piles, and the sewer pipe—a 48in diameter cast iron pipe laid in 12ft lengths—is held in the square enclosed by these four timbers.

The trestle is driven with both cross members bolted in position. This assists in maintaining the alignment of the piles and obviates the need for a diver to make the lower bolted joints, but means that some expedient is needed in the pile driving, to ensure that the two piles are driven together, without damaging these joints. In practice this has been done by rigging the piles for air and water jets at the pile shoe, as the drawings show. As far as we are aware, the use of compressed air to assist pile driving is quite novel, whereas water jetting is a standard practice. The contractor is patenting the air system, which has also proved useful in extracting piles, as well as providing sufficiently smooth driving for the two piles to be knocked down together without harming the assembled trestle. The hammers on the two frames—simple drop hammers—are not synchronised, but the driving is closely watched to keep progress even on the two piles. Air jetting is immediately obvious to the crew of the machine, since a good deal of foam is produced. Water jetting can be checked at the control station of the machine, where flow indicators have been installed.

The third major operation on this outfall was pipe laying. As already mentioned, some of the equipment was taken off the machine for this work, and a pipe slung between the two decks. A bogie could then be used to run out additional pipes, which could be moved into the well of the machine on a transfer bogie, if there were time on one tide to lay more than one pipe.

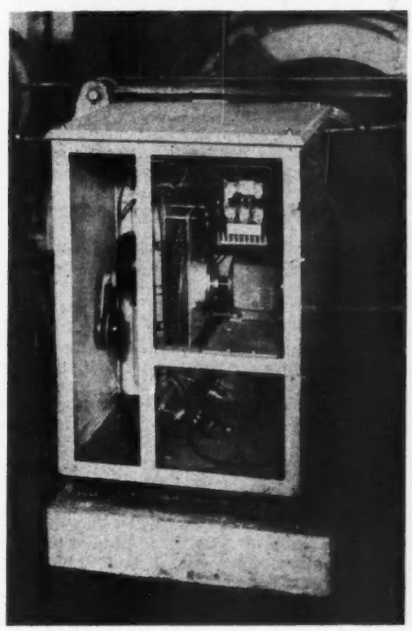
It is considered that the machine could be adapted for similar offshore construction to that at Shoreham Harbour, such as the construction of jetties, pipeline gantries and long groynes and breakwaters. In this case, the seaward 750ft of the outfall was built in ten months.

Automatic Slow-Down Equipment for Strip Mill

SAVINGS up to 10 per cent in the rolling of cold steel strip are being effected with a new slow-down equipment which has been installed in a cold strip rolling mill at the works of Lancashire and Corby Steel Manufacturing Company, Ltd.

It will be appreciated that, on manual operation, with the steel strip passing from one reel to another through rolls, it is difficult for the operator to judge the exact point at which to slow down the mill for reversing. The ideal condition is for the mill to slow down with the minimum number of turns left on the uncoiling reel to allow for maximum safety and ensure the least variation in gauge. If the operator slows the mill down too late, the strip can snatch off the uncoiling reel, with consequent damage and loss of time. The operator usually starts the slow-down too soon, thus wasting time at high speed and consequently valuable production. With several passes the amount of off-gauge material increases.

To meet this situation, the English Electric Company, Ltd., has developed automatic slow-down equipment for counting the turns on reversing cold strip mill reels during coiling and uncoiling. The equipment automatically determines the latest safe point to slow down the mill.



Mechanical (rheostatic) slow-down equipment installed behind a reel motor on a cold strip rolling mill

Two kinds of automatic slow-down equipment are available, one mainly mechanical and the other electronic. At Lancashire and Corby, the first installation of this new equipment, the mechanical one is used. It is built mainly in two frames for installation behind the reel motors. These frames are handed so that the standard design can be applied to both reels of a mill. We illustrate the unit with front cover removed. The maximum turns count is about 1600 but by changing the input gear ratio the equipment will count other than complete turns, for example, 800 turns of strip could be counted in half-turn steps, or 2400 turns in one-and-a-half turn steps.

The principle of operation is as follows. A circular rheostat gives an electrical output changing steadily as each fifty turns is wound on or off the reel. The rheostat output is disconnected by a geared limit switch after the first fifty turns when coiling so that it is only operative again during the last fifty turns when uncoiling. A sensitive " magamp " or relay compares the number of turns shown by the rheostat with the square of the strip speed. During uncoiling this quantity is rising while the number of turns remaining on the reel is falling ; at the correct point the " magamp " or relay operates and starts the slow-down, and during the slow-down maintains this comparison so that the slow-down may in fact take place in three or four stages. A signal proportional to the square of the strip speed is produced in a small machine contained within the slow-down unit and excited from the mill-driven pilot exciter or tacho-generator which would normally be provided for various control and indication purposes.

The maximum input speed for this exciter and for the slow-down equipment is 1400 r.p.m. The input shaft extension is left bare for a flexible coupling ; this coupling must allow for any float in the reel motor. The gear ratio between this input shaft and the slow-down mechanism is selected as required for each installation.

The rheostat is of new design but the moving parts are common to other English Electric rheostats. Life tests so far indicate that for the average single-stand cold reversing mill the rheostat can be expected to operate for years with very little attention. Magnetic clutches without sliprings or brushes are included to connect the rheostats, and the limit switch during counting and uncounting. Simple gravity-operated resetting devices are included for resetting the rheostat and the limit switch to zero when required.

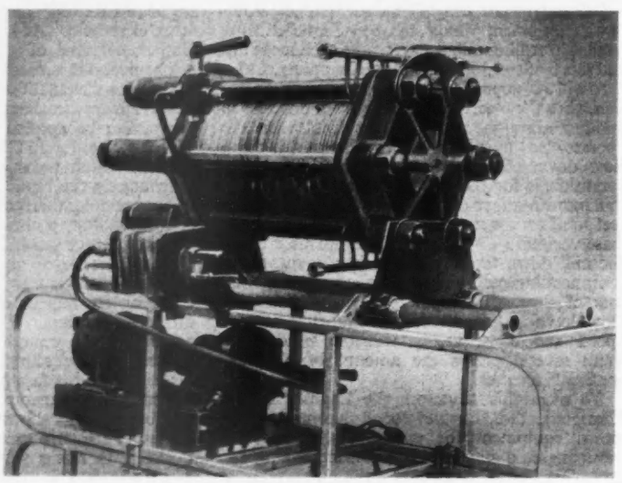
The equipment is intended for connection to a 220/230V d.c. supply. The total load for a complete equipment is about 2A. Various contacts must be made available in the mill control system for operating the slow-down equipment. These contacts are related to mill direction and speed and to strip tension on/off.

SHORTER REPORTS

Fuel Cell Progress

A DEMONSTRATION of a battery of forty hydrogen-oxygen fuel cells supplying electric power for industrial equipment was arranged on August 24 by the National Research Development Corporation at the premises of Marshall of Cambridge Electronics, Ltd., the Aerodrome, Cambridge, by whom the development work has been undertaken under the Corporation's sponsorship. The development contract was placed with the company in 1957, after ten years of original research had been carried out at Cambridge University by the inventor, Mr. F. T. Bacon, under the auspices of the Electrical Research Association and the Ministry of Power. Some abstracts from a paper by F. T. Bacon and J. S. Forrest on the high-pressure hydrogen-oxygen fuel cell appeared in our July 20, 1956, issue.

The stage of progress marked by the demonstration was the production of fully automatic control apparatus capable of working unattended. At present this is cubicle-mounted and provided with considerable instrumentation for test and observation purposes, but the essentials could be housed in a space some 30in long under the battery itself. Much work has been done on the control system to ensure the necessary very even balance between the pressure of the two gases. The system now evolved is to keep the oxygen pressure constant and to control the hydrogen pressure against it by a differential pressure meter, actuating a power-operated hydrogen inlet diaphragm valve controlled by a servo-mechanism. A single-stage reducing valve reduces the hydrogen bottle pressure to about 50 lb per square inch above the cell operating pressure.



Battery of forty fuel cells with hydrogen circulator and condenser

The largest battery evolved previously was one of six 5in diameter cells in series. The one now produced and illustrated herewith consists of forty cells, 10in in diameter and approximately ¾in thick, giving an output of 2½kW at 32V (or 5kW at 24V in maximum load conditions). Each unit cell consists of two electrodes, one for hydrogen and the other for oxygen, separated by electrolyte. The electrodes are made of porous sintered nickel with a thin layer of a smaller pore size on the liquid side. The oxygen electrode is treated with lithium and preoxidised to prevent corrosion. The electrolyte is strong caustic potash, and working conditions are around 200 deg. Cent. and 400 lb per square inch. The electrolyte soaks into the sintered metal but, on the application of the gas under pressure from the back of the plate, is expelled from the larger pores; the gas cannot bubble through the smaller-pored surface owing to the surface tension of the liquid. There is thus a very large surface of wetted sintered metal in contact with gas in each electrode—about 40 square metres.

Oxygen molecules on the positive electrode combine with water to form negatively charged hydroxyl ions which each remove an electron from the oxygen electrode. The hydroxyl ions migrate through the electrolyte to the negative electrode, where they combine with the hydrogen to form water, depositing an electron in the process. Thus, the hydrogen electrode becomes negatively charged with respect to the oxygen electrode and a current flows in the external circuit. In order to remove the water formed, the hydrogen is circulated past the back of the hydrogen electrode and the mixture of hydrogen and steam is cooled externally, so that the condensate can be released as required.

In the prototype installation at Cambridge, the cell is preheated electrically, but we were informed that oil-heating could be used if a battery had to be operated in a place without mains supply, and that no more attention would be required once it was working than periodical inspections, the temperature being self-maintained while the cell is active. Power for driving the hydrogen circulator is taken from the cell itself. For some duties it might be necessary to supplement the cooling with a motor-driven blower. During the demonstration the battery was seen operating a circular saw, delivering 60A at 32V, and supplying power for the manœuvring and lifting actions of a fork lift truck, when currents between 80A and 200A were recorded.

Power per unit volume (considering cell internal volume only) is 10·7kW per cubic foot, and power per unit weight (battery only) is 9·2W per pound, both at maximum output and 0·6V per cell. Open circuit voltage of a cell is 1V. At the rated output, assuming 0·8V per cell, the volumes (N.T.P.) of hydrogen and oxygen used per kilowatt-hour are 20 cubic feet and 10 cubic feet respectively.

The present stage of development of the cell, known as the "Hydrox" cell, has been described as "approaching the commercial proposition of a completely automatic and reliable battery." It is considered unlikely, however, that the fuel cell battery could ever be competitive with existing types of accumulators in small sizes owing to the high cost of control gear in comparison with the overall cost of the plant. Power outputs of less than 100W are not likely to be economic. With the advent of new methods of storing hydrogen and oxygen, either in liquid form or else, in the former case, as a compressed gas at a very low temperature, it is foreseen as conceivable that vehicles could be propelled over really long distances with fuel cells.

Plastic Packing for Cooling Towers

HEAD WRIGHTSON PROCESSES, Ltd., is providing two large "Counterflo" induced draught cooling towers for the Shell-Petrochemicals site at Manchester, and these, with concrete shell and structure, will incorporate the new plastic "Poly-Grid" packing, made from either high-density polyethylene or high-impact polystyrene, both of which are resistant to chemical attack and decay. Polystyrene is the less expensive material, but in certain circumstances high-density polyethylene is better.

The "Poly-Grid" packing is moulded in 3ft by 3ft grids with 2in sections having ⅛in "splash strips" along the top of each rib with 2in spacing between the decks by means of five tapered supports. The grids required for the Shell cooling towers will be manufactured from "Carlona," the high-density polyethylene made by Shell Chemical Company, and each grid weighs approximately 4 lb.

The packing offers the advantages of splash type packing with high operating efficiencies, and it is possible to increase the cooling capacity of a tower already installed by providing material which does not suffer from the deterioration problems of certain thin timber laths.

Relationships in Industry

A SCOTTISH CONFERENCE on "Relationships in Industry—Some Changing Concepts of Management" is being organised jointly by the British Institute of Management and the Ministry of Labour and is to be held at Gleneagles Hotel. Sir Alexander Fleck, Chairman of I.C.I., Ltd., will open the conference at 3 p.m., Friday, October 23, and on Saturday, October 24, Lord Monckton, Chairman of the Midland Bank, will give the address at the closing dinner. The object of the conference is to bring together Scottish industrialists to examine and discuss management responsibilities in relation to human problems in industry. The Chairman of the Conference will be Sir David Anderson, Director of the Royal College of Science Technology, Glasgow. The speakers—all prominent men from industry and education—will be: Professor Norman Hunt, of Edinburgh University, speaking on lessons to be learned from research into working relationships; Mr. Frank Donachy, of the British Transport Commission, on "Management and Men"; Mr. J. O. Blair-Cunynghame, Director of Staff, National Coal Board, on "Reconciling Security and Change," and Mr. Edward Denny, Chairman of William Denny and Brothers, Ltd., and Chairman of the B.I.M. Council for Scotland, speaking on some of the problems encountered by employers at the present time.

International Mineral Processing Congress

THE Institution of Mining and Metallurgy, 44, Portland Place, London, W.1, is to organise an International Congress on Mineral Processing to be held at Church House, Westminster, London, from April 6 to 9, 1960. The Congress will be the fifth in the series of international gatherings to discuss mineral processing problems, which began with a meeting in London in 1952, and has included meetings in France (1953), Germany (1955), and Sweden (1957). The scope of the Congress will extend to fundamental and applied research and development in the fields of mineral dressing and chemical processing, excluding smelting. Specialists from many countries have already offered papers, and as many as possible of these will be submitted for discussion. All proceedings will be in French, German and English by means of simultaneous translation. Preprints of papers, and the final volume of proceedings, will be published in English, with synopses in all three languages.

Plans are being made for members of the Congress to have an opportunity of visiting areas of the United Kingdom of particular industrial interest during the week following the Congress. It is also proposed to arrange a special programme for ladies in London during the Congress. Details and costs will be announced later.

Filtering Cement Slurry

A PROCESS for employing filtration to remove part of the water content from cement slurry before it is dried in the kilns has been developed by British Portland Cement Manufacturers, Ltd. This is stated to be the first time that filtration has been used in cement manufacture in Britain and it is believed to be the first cement manufacturing process in the world to use plate and frame presses, although rotary vacuum filters are used in some overseas countries. The filtration system has been developed at the company's Shoreham Works, in Sussex, where the raw materials used are, traditionally, chalk and clay, following the "wet" process of cement manufacture.

Nylon filter presses for dewatering cement slurry at the Shoreham works

Removal of some of the excess moisture from the slurry before it goes into the kilns is clearly advantageous, for it gives possibilities of increasing the output from existing plant, and also of enabling the amount of coal per ton of material to be reduced.

Work was started in earnest on the project in January, 1955. Investigations indicated that the solution lay with plate and frame presses rather than rotary vacuum filters since the better moisture extraction would more than outweigh the disadvantages of the process not being continuous. The results being achieved with nylon cloths on presses of this type in the potteries and collieries led to the decision to use nylon in this case.

The original filter plant at Shoreham went into use seventeen months after work had started. We are informed that to-day, after a prolonged period of trial, more than half the water in the slurry is removed by the process, the moisture content thus being reduced from about 42 per cent to between 18 and 19 per cent. This is considered to compare very favourably with the figure of 22 per cent generally achieved with rotary vacuum filters in the United States.

The installation at Shoreham consists of three 48in, eighty-leaf presses operating at a filter pressure of 120 lb per square inch. Each press is dropped about seventeen or eighteen times during a period of twenty-four hours and deposits somewhere around 10 tons of cake at a time, so that the capacity of the plant is between 3000 and 4000 tons per week.

After experiments it was found that the most satisfactory results were achieved with a 12½ oz per square yard continuous-filament plain-weave nylon fabric. The cloths are hosed down in the press room about once a fortnight. Records kept during a period of twelve months showed that the average initial life of a nylon cloth was 2000 pressings and that its total life after repairs was 3000 pressings, during which time it handled about 375 tons.

Adjustable Pot Cores

A NEW range of adjustable ferrite pot core assemblies for use in the manufacture of coils for many kinds of electronic and line communication equipment is announced by Mullard, Ltd., Mullard House, Torrington Place, London, W.1. "Vinkors," which are made from a new high-stability, low-loss grade of "Ferroxcube," incorporate a variable magnetic shunt by means of which the inductance of the assembled coil can be adjusted over a range of ±7 per cent and with an accuracy stated to be better than 0·02 per cent. The adjuster is readily accessible when the assembly is mounted in position, is self-locking, and is designed for adjustment with a screwdriver. Mounting is by a threaded shank and nut through a single hole in the chassis. A tag panel is incorporated to simplify wiring. The present range of "Vinkors" comprises five types for use at frequencies up to 200 kc/s, with outside core diameters of 18mm, 21mm, 25mm, 30mm and 35mm respectively. Each size of core is available with an effective permeability of 160, 100 or 63, as required. Single or multi-section coil formers of Polystyrene or low water-absorption nylon are available for each size of core.

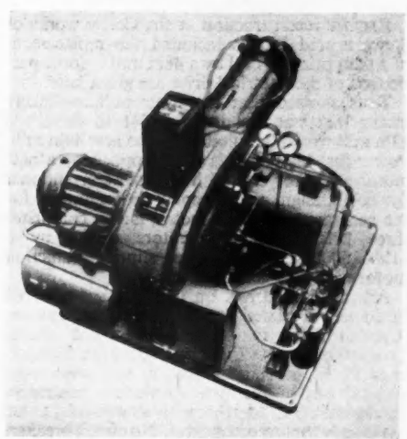
Tape Recorder for Airborne Use

BY the use of transistors in the electronic and power stabilisation circuits and printed circuits, Epsylon Industries, Ltd., Faggs Road, Feltham, Middlesex, has produced a long-playing recorder suitable for aircraft 28V d.c. supplies, and of weight and size rendering it readily portable for many other applications. The instrument, called the "Paraphone," is designed to operate unattended indefinitely and to give a total of forty hours' recording or replay before repeating. To achieve this length of play a two-track head is used on a cam assembly giving twenty positions for the heads on a 1in tape. The method of operation is such that twenty tracks of recording are made with one head and then a further twenty tracks are made with the second head. The tape runs in opposite directions for even and odd-numbered tracks, and a photocell actuates solenoids to change tape direction and move the heads from track to track. Adaptation to individual requirements is possible, such as provision for working from a 12V battery if the instrument is required for use in the field and a more readily transportable source of power than a 28V battery is desirable. The built-in loudspeaker shown in the illustration can receive the full 2W output or operate at low power for monitoring. Operation is by push buttons. Of the two "start" buttons, one provides a normal start from any position in which the tape has stopped, while the other, or "auto-start" button, causes the motor to respool to the beginning of the selected tape and then to reverse and play it.

Transistorised tape recorder for 28V d.c. operation

S.B. Oil Burner

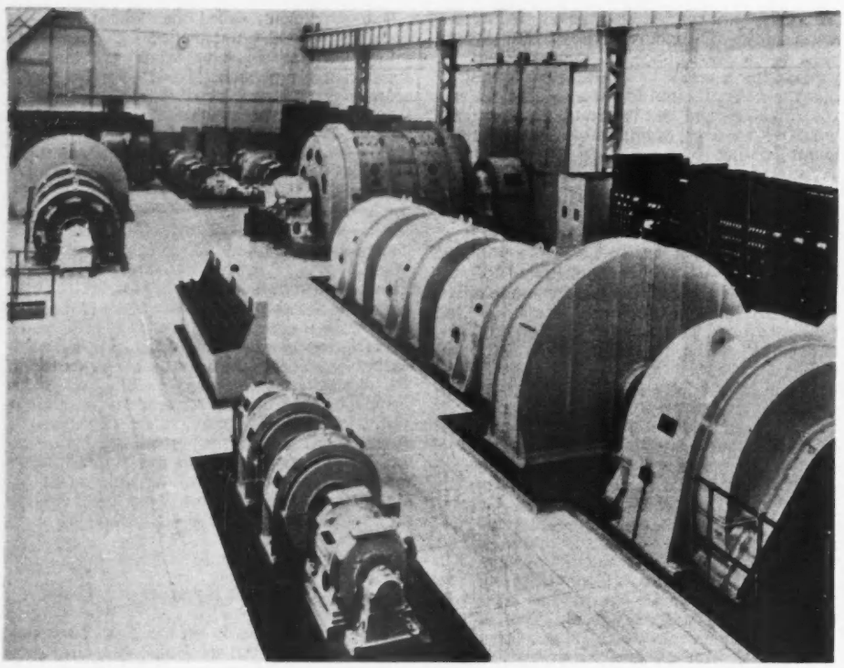
NU-WAY HEATING PLANTS, Ltd., of Droitwich, has developed, from its model ZH fully automatic commercial burner, new S.B. models, one of which we illustrate, which are primarily intended for the efficient firing of steam boilers at lower capital cost. The burners are particularly suitable for firing boilers which offer high resistance to the flow of combustion gases. To achieve this the fan pressure on the S.B. design has been substantially increased to produce a convergent air blast at the nozzle, which is strong enough to play a significant part in atomising the oil and promoting rapidly completed combustion. The resulting flue gas velocity is high enough to overcome substantial boiler and flue resistance which would cause ordinary burners to pulsate and smoke.



An S.B. burner

An advantage claimed for this new atomising system is that the combustion chamber volume required for a given rate of firing is greatly reduced. Vertical boilers fired with the burners can usually accommodate a firebox of sufficient size without excavation or extending the boiler skirt, thus reducing installation costs and time. The burners can also be applied to shell boilers to give, it is stated, combustion efficiency combined with installation costs which compare favourably with other oil-firing systems.

These burners are manufactured over a wide range of sizes for different grades of oil and all but the smallest can be supplied with "Nu-Way" high/low/off control, which gives appreciable fuel savings, inhibits pulsation on light-up, and stabilises steam pressure.



48in mill motor room at Stewarts and Lloyds, Corby, showing M-V 7500 h.p. main motor and associated motor-generator set, exciter sets and control gear. This mill has automatic programmed position-controlled screwdowns

Rolling Mill with Programme-Controlled Screwdowns

RECENT reconstruction at the Corby works of Stewarts and Lloyds included the replacement of a 42in primary mill by a 48in mill. Some particulars of the electrical drive are given here.

Tests showed that the Metropolitan-Vickers motor that was installed in 1941 to drive the 42in mill would be suitable for the new 48in mill. Power for this motor is now supplied by a new motor-generator set; it is of conventional flywheel design, with amplidyne excitation for the generators and mill motor, and it comprises three 2000kW d.c. generators driven by a 11kV, 5000 h.p., 600 r.p.m. slipring induction motor with a 35-ton flywheel.

All auxiliary drives on the mill are powered by forced-ventilated, standard mill type motors, supplied from two amplidyne-excited Ward-Leonard m.g. sets. Eight generators are normally used for the auxiliaries, but, in emergency conditions, one of the two screwdown generators can be switched, together with all controls, to act as standby for any other drive. No circuit breakers or main line contactors are used in any of the Ward-Leonard circuits, but current-limit control is provided on all Ward-Leonard auxiliaries. The mill motor, and all machines on the m.g. set, were made suitable for a forced ventilation recirculating air system included in the order.

The screwdowns on this mill are controlled from two automatic programmers—one supplied by the Digital Engineering Company, Ltd., and the other by Metropolitan-Vickers Electrical Company, Ltd. The latter programmer uses standard teleprinter-type punched paper tape and is arranged to provide any one of fifty rolling schedules at the turn of a switch. A greater number of programmes could be catered for, but fifty is considered enough in this instance. The remote-position servo for both programmers was supplied by Metropolitan-Vickers Electrical Company and uses 50 c/s flux-resetting type amplifiers.

The changeover from the 42in to the 48in mill was carried out in just under ten and a half days.

International Association for Bridge and Structural Engineering

LAST week, the permanent committee of the International Association for Bridge and Structural Engineering held its annual meeting in Edinburgh. About a hundred engineers from seventeen countries attended, and the affairs and accounts of the Association were dealt with and various officers elected. The Association's executive committee was also active in arranging details of the next full-scale congress which the Association will hold, which will be in Stockholm, over the period June 27 to July 1 of next year. During the week the permanent committee members visited the site of the new Forth road bridge, Hunterston nuclear power station site, and Glasgow Corporation's Loch Katrine waterworks. They were received by the Lord Provost of Edinburgh, Mr. Johnson-Gilbert, on the Monday and by Lord Forbes, Minister of State for Scotland, on the Wednesday.

Auger for Cylinder Piles

THE accompanying illustration shows a lorry-mounted drilling rig equipped with an auger for excavating large-diameter shafts for "cylinder" piles. The drilling rig itself is of U.S. manufacture and is mounted on a Foden chassis. It is being used by McKinney Foundations, Ltd., a company of U.S. parentage, but associated in this country with John Laing and Son, Ltd. The latter firm is at present building a sixteen-storey office block in London at the corner of Gower Street and Euston Road, and the rig is in use there.

Readers may recall that a rig for similar duty, but in this case mounted on an excavator, was described in this journal in our "emergency" issue of June 26 last, when the advantages of large-diameter cylinder piles in soils such as clay were commented upon; we also published, in our issue of August 30, 1957, an account of the soil mechanics aspects of such a foundation.

The equipment described here has a 78ft jib and its total weight is 24 tons. It can drill shafts up to 8ft in diameter and 110ft in depth, at a speed given as "several feet a minute," and it is claimed that it offers "considerable economies . . . by virtue of its greater speed in comparison with other methods." The auger has four "turns," as can be seen, and has a hardened steel cutting edge; it is withdrawn from the shaft when "full" of spoil, and spun in reverse to unload it. There is a belling-out attachment for the bases of the shafts. Operation of the lowering mechanism for the jib and of stabilising legs, which can be lowered on either side of the chassis, is hydraulic. At the Gower Street site, 145 shafts, up to 60ft in depth, will be excavated.

Lorry-mounted auger for constructing large-diameter foundation shafts

Factory for Fabricating Pressure Vessels

A NEW factory, which has been opened on the site of Crown Works, Sunderland, by Steels Engineering Installations, Ltd., is specially equipped for the manufacture of pressure vessels, heat exchangers and associated classes of plant for the chemical, oil, nuclear and allied engineering industries. The main factory building has two parallel production bays, 150ft long, one being 40ft and the other 30ft wide. Set at right angles along one end of these two bays is a third "high" bay for assembling the component parts delivered from the production shops.

The two production bays are served by 10-ton overhead travelling cranes, the gantries of which are cantilevered out some 10ft into the high bay to facilitate the transfer of heavy sub-assemblies and components. The high bay is served by two 20-ton overhead cranes and the crane gantry at one end is extended beyond the building over a rail track and road to allow the direct loading of heavy work on to vehicles. Two branch sidings extend from this rail track, one leading to a stress relieving furnace and the other to a materials stockyard.

The larger production bay is equipped for the fabrication, machining and forming of plates, and its equipment includes heavy rolls, edge planing, edge setting, gas cutting and other machines used in modern plate preparation practice. The smaller bay is laid out for the manufacture of the tube bundles and smaller parts for heat exchangers. From these two bays the plates and tube bundles are taken to the high bay for welding and assembly. In this shop an automatic 120A d.c. welding machine is used for welding all main and longitudinal seams on vessels and the welding of such things as nozzles and flanges on dished ends. A number of welding machines of up to 600A capacity are installed for hand welding operations in this shop, and equipment is available for submerged arc, open arc or inert gas shielded welding, according to the requirements of particular classes of work. Full facilities have been installed for the stress relieving, hydraulic testing and X-ray inspection of equipment.

Industrial and Labour Notes

Engineering Exports

The Board of Trade has issued a commentary on the figures for overseas trade in July. In that month engineering goods showed the same increase as for all exports (5½ per cent) compared with the average for the first six months of 1959. Two-thirds of this increase was attributable to ships and boats, which were double the average for the first six months. On the other hand, aircraft, another commodity which is susceptible to large monthly fluctuations, fell by £4,000,000, which compares with the rise in ships and boats. Non-electric machinery also rose by 5½ per cent and the rise was shared by most types, but exports of aeroplane engines were outstanding, and at £6,000,000 they were 17 per cent above the average for the first half of this year. Exports of electric machinery and appliances showed a more modest rise of 2½ per cent, which was mainly accounted for by a rise in exports of heavy electrical machinery. Exports of railway vehicles were 12 per cent lower and scientific instruments, &c., showed an average rise. Exports of cars and chassis have remained again buoyant with an increase of 13 per cent over the first six months, and over three-quarters of the rise was due to increased deliveries to North America. Commercial vehicles and chassis showed a rise of 7½ per cent, with Australia, Ghana and Western Europe taking more. Exports of metals in total were 12 per cent higher in July compared with the rate for the first six months of the year. Shipments of iron and steel improved by 22 per cent, non-ferrous metals remained steady and metal manufactures showed an increase of 7½ per cent.

Exports of Radio Equipment

With a provisional value of over £26,000,000 for the first six months of 1959, radio equipment exports this year are considered likely to exceed £50,000,000 for the twelve months—the first time this figure will have been attained. In 1958 the value for the first six months was £22,000,000, and £46,500,000 for the whole year. Exports of sound reproduction equipment and of radio and electronic components were over £5,000,000 and of valves and cathode-ray tubes nearly £3,500,000. Other exports were nearly £11,000,000 of capital goods produced by members of the Electronic Engineering Association, and this does not include equipment in ships and aircraft valued at several million pounds.

Coke in Ironmaking

The British Cast Iron Research Association is to hold a three-day meeting in Birmingham and Coalbrookdale from September 23 to 25 to commemorate the 250th anniversary of the successful use of coke in ironmaking in 1709 by Abraham Darby, the Quaker ironmaster and founder. Before that time the small output of iron in this country had relied on charcoal as the reducing fuel. The meeting has been organised by a national committee under the leadership of Sir Frederick Scopes, chairman of the Stanton Ironworks Company, Ltd., who is also Chairman of the British Coking Industry Association. The proceedings will open at the University of Birmingham on the evening of September 23 with an introductory lecture on the economic and social background of the iron industry in the eighteenth century by Professor T. S. Ashton. Four papers will be discussed at the University on the following day: an account of the charcoal iron industry, by Mr. B. L. C. Johnson of the Geography Department at Birmingham University; the contribution of the Darby family to the development of ironmaking, by Dr. A. Raistrick; a study of the events at Coalbrookdale in 1709, by Dr. R. A. Mott, of the British Coke Research Association; and a contribution on the history of iron-founding by Dr. J. G. Pearce, who recently retired from the office of Director of the British Cast Iron Research Association. On the evening of September 24, a dinner will be held at the Grand Hotel, Birmingham, at which the principal guests will be Lord Mills, Minister of Power, and Lord Bridgeman, Lord Lieutenant of Shropshire. Finally, on September 25 there will be a visit to Abraham Darby's furnace at Coalbrookdale, which has been restored by Allied Ironfounders, Ltd., who have also established a museum nearby.

Revised Coal Output Plan

A revised plan for coal production in the next five years has been communicated by the National Coal Board to leaders of the National Union of Mineworkers and representatives of other employees' organisations preparatory to its submission to the Minister of Power. The target of 240 million tons a year by 1965, which was set up six years after the original "Plan for Coal" of 1950, has been modified on the basis of an estimated demand five years hence of between 200 million and 215 million tons. It is expected that over the period to 1965 economic reasons will necessitate the closing of between thirty-five and seventy pits, additionally to "normal closures" of 170 pits in that period. Much of the reduction in planned output is proposed at the opencast sites, and according to the plan opencast production will fall to 2,000,000 tons by 1965 and be concentrated at two major sites. It has also been stated that investment could be appreciably reduced from the figure of £400 million foreseen earlier for the next six years. Further review of the plan has been delegated by the National Union of Mineworkers to an economic sub-committee.

Iron Castings Production

The Iron and Steel Board states that the production of iron castings in the second quarter of 1959 was 878,590 tons. Production in the second quarter of last year was 887,210 tons, or 1 per cent higher. A commentary on the figures issued by the Joint Iron Council points out that generally, owing to seasonal factors such as the incidence of holidays, the second quarter's output in any year is lightly lower than that of the first. This year, however, all sections of the industry, except that providing railway equipment, show an increase in their second quarter's production compared with that of the first quarter of 1959. Railway equipment castings output was 3·2 per cent down compared with that quarter, and 30·8 per cent lower than in the second quarter of 1958. The automobile section established a new record with a second quarter production 13 per cent higher than ever before recorded. The engineering section showed an increase of nearly 5 per cent compared with the first quarter, but failed to reach the level of a year ago. Pressure pipes and fittings, with a rise on the quarter of 10 per cent, virtually reached the production of the second quarter last year. The production of building and domestic goods castings changed little compared with the previous quarter, but maintained a rate of output noticeably ahead of corresponding periods in 1958. Ingot mould production rose significantly in the quarter, but, in line with the output of its customer industry—steel—was slightly below the second quarter of 1958. The overall change from the previous quarter of this year was a rise of 6·1 per cent.

Aircraft Industry Redundancy

Aircraft workers at the Belfast factory of Short Brothers and Harland, Ltd., who had been on strike since August 11 over the proposal to pay off some 1200 redundant men by the end of the year, resumed work on August 21. The return followed a meeting between representatives of the Confederation of Shipbuilding and Engineering Unions and Lord Brookeborough, Prime Minister of Northern Ireland, who promised to put to the firm representations made to him by the unions on the subject of redundancy and their suggestions for work sharing.

Machine Tools

Statistics for May, 1959, issued by the Machine Tool Trades Association show net new home orders of £6,166,000, compared with £4,171,000 in 1958, and export orders of £1,608,000 against £1,140,000. The home order book at the month end stood at £35,966,000, a decrease of £13,772,000, while the export order book at £15,700,000 was lower by £1,267,000 than in May, 1958.

Export of Iron and Steel Scrap

At the request of the Ministry of Power, the Board of Trade has announced arrangements permitting the continued export of specified types of iron and steel scrap. An Open General Licence has been issued permitting during the period September 7, 1959, to December 8, 1959 (inclusive), the export to any destination of scrap and old metal consisting wholly or mainly by weight of iron or steel and having an f.o.b. value not exceeding £25 per ton in the following forms:—(*a*) compressed baled material, and (*b*) scrap turnings and borings. Inquiries about this licence should be made to the Board of Trade, Export Licensing Branch, Gavrelle House, Bunhill Row, London, E.C.1. The effect of this Open General Licence is to permit the free export of specified grades of iron and steel scrap authorised by the Current Open General Licence (which expires on September 6, 1959) to continue until December 8, 1959.

Radio Telephony in French Express Trains

On four trains daily in each direction between Paris and Lille passengers are now able to make telephone calls to and from the P.T.T. system during the journey. The facility is provided by a v.h.f. link between the trains and a chain of eleven lineside stations with a cable connection to a Paris exchange.

WITH the introduction of eight new five-coach train sets of stainless steel rolling stock on the electrified Paris-Lille route, the French National Railways have made available a radio telephone service between passengers in these trains and telephone subscribers in France or other European countries. These facilities are available in four services in each direction daily, five of which make the Paris-Lille journey of 155½ miles in 2 h 10 min. A buffet car in each train is provided with a call box, transmitting and receiving equipment and roof-mounted aerials for communication through a chain of eleven fixed stations with the general telephone network. The mobile and fixed radio apparatus has been supplied by the Société Française Radio-Electrique (S.F.R.), of 41, Rue Sartoris, La Garenne-Colombes (Seine), a member of the Compagnie Générale de T.S.F. group of companies.

Telephony with S.F.R. equipment between a moving train and the telephone system was demonstrated when the first section of the French National Railways Lille-Basle 25kV a.c. electrification was opened in May, 1955, and two years later the company undertook further trials on the Lille-Charleville section of this route. The installation now in service on the Paris-Lille line, the electrification of which at 25kV a.c. was formally inaugurated on January 7 this year (see our January 23, 1959, issue) comprises eleven fixed transmitter-receiver stations at the lineside working with the transmitter-receivers in the trains. Phase modulation is used, as this form of frequency modulation has been found to give freedom from electrical interference by the traction system provided there is at least one coach length between the locomotive pantograph and the train aerials. Three radio frequencies are used, as follows :

Train to lineside stations	156 Mc/s
Lineside stations to train	160·6 Mc/s 160·8 Mc/s

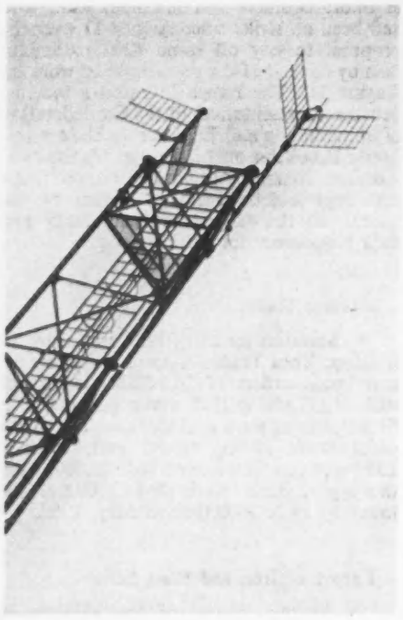


Fig. 1—Aerial systems and reflectors for beaming signals in both directions along the railway track

Two fixed station transmitting frequencies are necessary because these stations are sited so that their service areas overlap, to ensure continuity of reception. A single frequency would cause interference unless the transmissions from adjacent stations were exactly synchronised. In practice, therefore, the same frequency is used by alternate stations so that in any adjacent pair the two transmitters are working on different frequencies. Both are sufficiently removed from the train transmission frequency to allow duplex working.

The fixed stations are at intervals of 12 to 15 miles. Their aerial systems (Fig. 1) are supported on lattice towers of heights between approximately 100ft and 200ft, according to site conditions, and consist of two directional aerials beamed up and down the track by means of two reflectors at 90 deg. for each direction. The transmitter-receiver equipments are housed in huts at ground level (Fig. 4) and are connected with the aerials by means of low-loss coaxial feeders. Power supplies are taken from the cables feeding the railway signalling system.

Connection between the fixed stations and the telephone repeater station at Paris Nord is by means of two pairs in the railway telecommunication cable which follows the route, one pair being used for transmission and the other for reception. An amplifier with automatic gain control is provided at each station to compensate for attenuation in the transmission pair and to provide a satisfactory input for transmitter modulation. Similarly, the receiver output is controlled so that a steady signal is fed to the reception pair. There are further amplifiers for both directions at Paris Nord, and the final connection with the telephone system is made through a hybrid transformer to a two-wire circuit terminating on a manual switchboard at the Roquette exchange.

The method of calling, and of preventing break-in when a connection has been established, is based on the use of three audio-frequencies. When no messages are passing, a 1400 c/s tone is sent out continuously from Paris so that all fixed transmitters are modulated at this frequency. This transmission is cut off automatically either when a call is received from a train, or when the Paris operator initiates a call. This is done by plugging into one of two jacks connecting with the cable to the fixed stations. According to the jack selected, a d.c. potential of plus or minus 48V is applied to the transmission pair in parallel and causes a modulation frequency of either 1800 or 2400 c/s to be radiated by the fixed transmitters. One of these tones corresponds with each direction of travel, and so the train equipments have to be set up by means of a changeover switch to respond to one or the other before leaving the termini. Reception of one of these tones rings the telephone bell in the train being called until the handset is lifted. At the same time the 1400 c/s "system free" tone is cut off and this has the effect of blocking the transmitter of a train running in the opposite direction, simultaneously lighting a "system engaged" lamp on its telephone control panel. At the end of the call the Paris operator disconnects and the "system free" tone is again radiated, freeing all transmitters. The timetable is arranged so that only one telephone-equipped train is running in each direction between Paris and Lille at any given time. Therefore, a single calling tone for each direction meets the requirements of identifying the train required and preventing the other from transmitting during a call.

A train can only call Paris while the "system free" tone is being radiated. Lifting the handset causes the audio-frequency allocated to the train to be transmitted, and when this is received at Paris it cuts off the "system free" tone and calls the operator, who plugs into the jack.

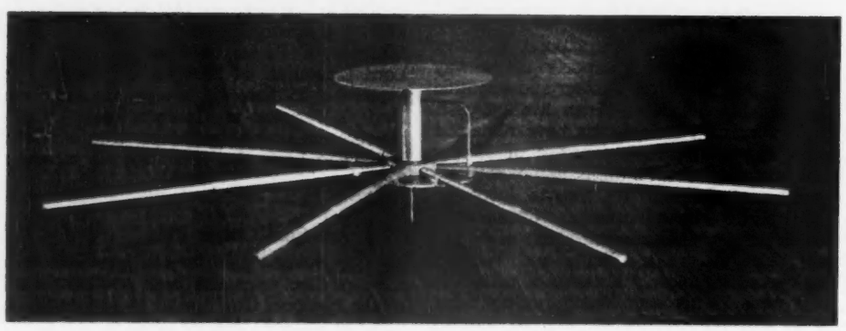


Fig. 2—Aerial system for mounting on roof of coach

Fig. 3—Telephone control panel and train loudspeaker system microphone in buffet car

The terminal equipment at Paris Nord enables the working of the fixed stations to be monitored and the continuity of the cable circuit to be checked. Stations are called selectively by a code based on two audio-frequencies, reception of which causes the transmitter chosen to be switched for a few seconds to the receiver frequency, and a weak signal of adjustable level to be applied to the receiver and returned over the cable to Paris.

In the trains the radio telephone apparatus is installed in a buffet car alongside a soundproof telephone box for the use of passengers. The equipment comprises a crystal-controlled transmitter and two receivers tuned respectively to the two fixed station transmitting frequencies. An automatic changeover switch brings either receiver into operation, according to the relative field strengths of the transmissions from the two fixed stations within the range of which the train may be. To prevent frequent switching in transient conditions, the arrangement is adjusted so that the inoperative receiver is not switched in until the field strength of the transmission to which it is tuned has exceeded that of the transmission actually being received by a certain value and for a certain time. It is found in practice that the occasional switching between receivers causes no perceptible breaks in conversation.

Power supplies are taken at 127V a.c. from a rotary converter operated on the coach 72V battery supply, and are used also for the train

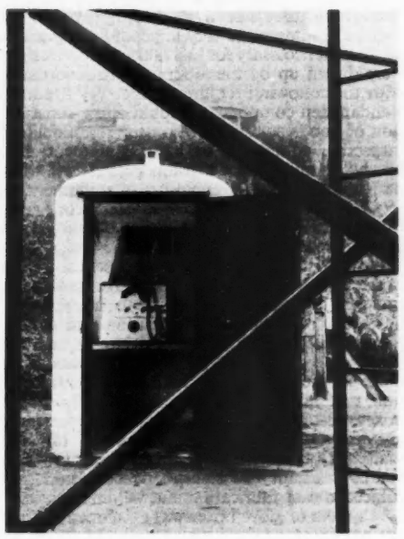


Fig. 4—Transmitter-receiver installation at foot of aerial tower

loudspeaker installation. Two aerials of special design (Fig. 2) are mounted on the coach roof, one at each end, one being connected to the transmitter and the other being common to the two receivers, which are connected to it through an r.f. preamplifier. Both are omnidirectional disc aerials designed to conform with the loading gauge when mounted on the roof. They take the form of a vertical cylinder 7in high, supporting a disc 11in in diameter, from which radiate eight rods with a length of 2ft 1½in. The aerial gain is identical with that of a normal quarter-wave system.

A control panel with telephone handset (Fig. 3) is mounted behind the buffet car bar counter and is in charge of the bar attendant. Push-buttons for starting and stopping the equipment and for giving priority to the control panel or the telephone-box handsets are arranged on this panel, together with the frequency changeover switch (Paris-Lille or Lille-Paris) and signal lamps showing "system free," an incoming call, and "engaged." In the adjacent telephone box a time clock is provided and a luminous signal operated by the bar attendant indicates when conversation may begin. When a call is received in the train, the bar attendant uses the train loudspeaker system to summon the traveller to whom it is addressed.

Calls originating on a train are charged as if made from Paris (with a minimum of Fr. 125 for three minutes), plus a surcharge of Fr. 200. If a number called is unobtainable, no charge is made.

A subscriber calling a passenger in a train pays the cost of a call to Paris (with a minimum of Fr. 125), plus a personal call fee of Fr. 150. If the person called is not travelling on the train, only the personal call fee is charged. A charge of Fr. 200 is made to passengers receiving telephone calls during a journey.

Mannesmann Aktiengesellschaft

The General Annual Meeting of Mannesmann Aktiengesellschaft, Düsseldorf, took place on July 16. In its report on the year January 1–December 31, 1958, the Board of Management deals with the consolidation into a single company of the concern's six principal subsidiaries (Mannesmannröhren-Werke A.G., Mannesmann-Hüttenwerke A.G., Hahnsche Werke A.G., Gewerkschaft Mannesmann, Mannesmann Rohstoffwerke G.m.b.H., and Essener Steinkohlenbergwerke A.G.) which now function as divisions of Mannesmann A.G. This measure restores the *status quo* before the deconcentration measures imposed after the war. The report sketches the advantages which are expected to accrue from the re-organisation.

The capital of Mannesmann A.G. was increased during the year from 560 million to 580 million D.M. The external turnover of the six principal constituent companies amounted to 3315 million DM. (1957 : 3566 million DM.), of which the trading companies accounted for 1076 million DM (1273 million DM.), the producer companies for 2239 (2293) million DM. Raw materials (coal, ore, &c.) accounted for 336 (384) million DM., rolled steel and tube semi-products for 513 (513) million DM., tubes and tube products for 893 (907) million DM., other secondary processing for 458 (442) million DM., and sundry deliveries for 39 (47) million DM.

Tube production amounted to 752,000 tonnes (−7·6 per cent), crude steel production was 1,810,000 tonnes (−9·2 per cent), rolled steel production 1,018,000 tonnes (−10 per cent), iron ore production 282,000 tonnes (+5·2 per cent), and coal production 6,760,000 tonnes (+1·8 per cent). Total employment at Mannesmann and its domestic subsidiaries decreased from 76,400 to 73,600 because of reductions in the coal-mining, smelting and tube divisions, while other branches and the foreign subsidiaries showed increases.

Additions to equipment included a second sintering plant at Huckingen, as well as a new casting and stripping bay in the Thomas steel plant there, also harbour extensions and progress with the new coke-oven plant. Hahnsche Werke commissioned a new broad strip mill, and a press was installed for producing 6m-long corrugated sheets, the longest size current in Germany. Research proceeded in connection with heat transfer in tubes (reactor technology), special titanium and zirconium alloys and high alloy steels, and plastic coatings and tubes. The development of weldable structural steels with additions of nitrogen, manganese and vanadium was successfully concluded.

European Economic Co-operation

In a recently published report* the O.E.E.C. surveys its recent activities in each of the main fields covered by this organisation. A good deal of the work last year was in connection with the negotiations for a Free Trade Area which were eventually suspended last November. Following the successful fight in 1956 and 1957 against inflationary pressures and external payments disparities, the Organisation in mid-1958 recommended its member countries to re-orient their policies to renewed expansion of production, and in fact a shift towards expansion has been observed in recent months. A new monetary and payments arrangement was worked out to replace the European Payments Union under conditions of convertibility ; help was given to France and Turkey to overcome balance of payments difficulties. Technical assistance was given by EPA to accelerate progress in backward areas. Long-term energy problems were studied by an advisory commission which will issue its report this year. At the end of 1957, O.E.E.C. established its European Nuclear Energy Agency (ENEA) which last year set up "Eurochemic" for the chemical processing of irradiated fuel. This company, in which twelve member countries and Spain are participating, is constructing a pilot plant in Belgium for the processing of natural uranium and the extraction of plutonium. Two other joint ENEA projects have been developed, the first concerning an experimental boiling water reactor in Norway, the second for the construction and operation, together with a programme of research, of an advanced high temperature gas-cooled reactor in the United Kingdom. Another major objective is to develop legislation in this field (draft convention on third party accident liability ; protection against radiation dangers). ENEA is also active regarding international trade in nuclear materials, personnel training, and security control to ensure its activities do not further military purposes.

In order to contribute to the easing of the present shortage of scientific and technical manpower, O.E.E.C. in the spring of 1958 set up an Office of Scientific and Technical Personnel, to help improve the existing facilities for the training of teachers and the exchange of information. Practical results are already being achieved.

The report suggests a number of tasks for 1959 and after, concerning the development of trade, industrial and agricultural production, science, and the industrialisation of less-developed countries.

* "The Work of the Organisation for European Economic Co-operation." A report by the Secretary-General. Paris : O.E.E.C., 2, rue André-Pascal, Paris, 16e. Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 7s.

Auto Collimators

After extensive investigations into the needs of inspectors checking large jigs for the motor and aeroplane industry and the requirements of machine tool makers, M. Hensoldt and Söhne, Optische Werke A.G., Wetzlar, has modified its auto collimators to suit the applications mentioned. Two models are now available, one with micrometer eyepiece reading direct to one second, and the other with fixed reticule reading to thirty seconds. Both instruments have a scale range of thirty minutes and readings can be taken up to 30ft from the reflector. The plane and polygonal mirrors and the optical prism for deflecting the beam through 90 deg. are mounted on magnetic bases to ensure greater reading stability and prevent them being dislodged by any accidental blow or sudden vibration. The instruments are available in this country from Degenhardt and Co., Ltd., 6, Cavendish Square, London, W.1.

Materials Testing Journal

With the inception of a monthly entitled "Materialprüfung — Materials Testing — Matériaux Essais et Recherches" the German Association for Testing Materials (DVM) has created an international forum for the exchange of views and the assembly of documentation. Contributions will be published in either German, English, or French, with summaries in all three languages. The first issue, dated January 20, contained main articles on "The hydrogen embrittlement of steel" (Paul Bastien, Paris), "The comparison of notched bar tests over the temperature transition range" (A. W. Johnston, East Kilbride), "Materials testing and the prevention of damage" (Hermann Selle, Berlin), "The German Standards Committee for Testing Materials (FNM)" (N. Ludwig, Dortmund), and "The Swiss Federal Materials Testing Institute (EMPA)" (Ed. Amstutz, Zürich). The remaining sections contained technical notes, announcements, notes on standards and standardisation, personal notes and documentation. Current titles are listed in order of UDC numbers, an arrangement which greatly facilitates quick reference.

Fuel Fabrication at Argonne National Laboratories

BY OUR AMERICAN EDITOR

No. II—(*Concluded from page* 125, *August* 21)

With the recent dedication of the fuel fabrication facility at the Argonne National Laboratory, Lemont, Illinois, an important milestone has been passed in the field of plutonium application in the American atomic energy programme. The new facility was built by the U.S. Atomic Energy Commission at a cost of some 4,000,000 *dollars and is devoted to the development of plutonium fuel element fabrication techniques and the manufacture of such elements for various American reactors. The special hazards associated with plutonium required the facility to be designed with various safety aspects, including extensive hood enclosures and a recirculating helium atmosphere system.*

AIR is supplied to each of the three main operating areas by means of a separate air-conditioning system. Replaceable filters are employed on the air supply to the technical and fabrication areas. The air supply is humidity-controlled. The exhaust ventilation of the fabrication area includes three systems : (1) A once-through system for exhausting air from the process enclosures where work is done on reactor fuel pieces. (2) An emergency stand-by or purge system which operates constantly and which, in the event of failure of the normal ventilation, is automatically opened to provide ventilation of the process enclosure. (3) A once-through filtered air system to exhaust the room air and to ventilate auxiliary equipment housed in secondary enclosures below the primary process enclosures.

The philosophy of preventing air-borne radioactive dust from spreading between areas of the building is to keep air moving inward so that there is no leakage from the technical area to the administration area or from the fabrication room to the technical area even when air locks are opened. This is done by keeping the technical area at a lower pressure (0·05in water gauge lower) than the outer atmosphere, and the fabrication room, where radioactive dust is most likely to originate, at a still lower pressure (0·125in water gauge lower than atmospheric pressure). The technical area is established as a reference zone against which fabrication area and administration area pressures are set by means of exhaust fans and dampers. The administration area is kept at approximately atmospheric pressure.

About one-half of the building is excavated below grade. This space is divided into basement " A ", which houses process equipment services, and basement " B ", which houses normal building services such as heating, air conditioning, and stand-by electrical generation equipment. The pressures on the basement are controlled by the technical area ventilation system. All the air exhausted from the building is filtered through high efficiency fire-resistant filters. These filters are tested to be effective against 99·95 per cent of all $^{1}/_{10}$ micron size particles before installation. Double filter banks in series are used to remove contamination from the air exhausted from all highly contaminated areas such as the inside of the hoods. Single filter banks are employed for room air exhaust purposes. In addition to double filtration, all the air exhausted from contaminated zones is piped through a 100ft high stack at the south side of the building. This allows for the dissipation of any gaseous radioactive process products that may remain to a value well below maximum permissible limits.

Hood Enclosures

To protect the operating personnel in the fuel fabrication facility, Argonne considered several methods of providing safety against alpha particle contamination and decided on an integrated system of hoods or glove boxes branching out from each other in a herringbone pattern (Fig. 6). Gasketed together to prevent air leakage, these hoods may be used with either air or a helium atmosphere, depending on the materials or operations. There are 106 of these hoods in the building ; they range in volume from 18 to 800 cubic feet.

After three years of design work at Argonne, the plans for the hoods were completed, and prototype models were built and tested. The Cook Electric Company, of Chicago, built the hoods to the Laboratory's specifications. Four types of work will be carried out in the hoods of the Fuel Fabrication Facility. These are : (1) Fabrication of, or work directly upon, reactor fuels containing plutonium alloys. (2) Assembly, welding and bonding of previously fabricated plutonium cores in non-radioactive jacket materials. (3) Metal working, machining, cutting, or heat treating operations upon the jacketed pieces. (4) Inspection or other operations upon finished fuel-elements for which no protection is required.

A special hood line (PF-4) is used to introduce materials into or remove them from the system. Non-radioactive and packaged materials are introduced through a system of locks at one end of this special hood line. Contaminated materials are removed from the hood system without exposure to room air by a plastic pouch transfer technique. The operating hood lines are interconnected by means of a 102ft long hooded conveyor (PF-3). The conveyor (Fig. 7) consists of two rails upon which a dolly is drawn by a continuous roller chain. Transfer from the conveyor line to the operating hood lines, PF-5 to PF-14, is made on two-way ball-bearing slide platforms. These may be projected into either the conveyor or into the operating line. Each operating hood line is separated from the conveyor by means of a gas-tight, pneumatically operated sealing door. The transitions and operating hood lines were laid out with their longitudinal axis at 135 deg. from the axis of the conveyer line allowing the transfer of pieces 6ft to 8ft long into a conveyor enclosure only 30in wide.

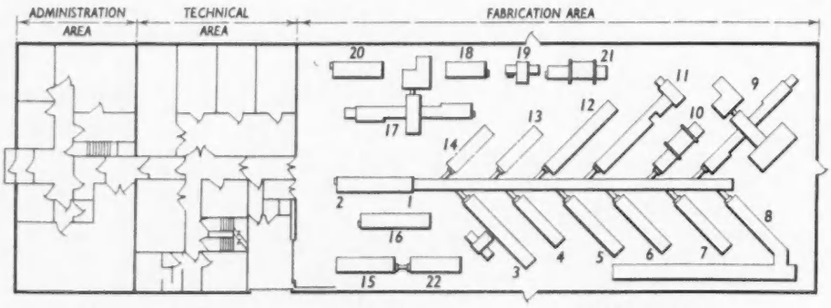
The glove boxes (Fig. 8) are themselves supported upon the housings of contamination risk equipment, such as vacuum pumping systems and hydraulic systems. This equipment will not normally be radioactive but may become contaminated due to the failure of gaskets or seals. A water cooling system within the hoods will be operated at negative pressure with respect to hood atmosphere. Provision is made for an inert helium atmosphere in all hood lines connected to the conveyor line except the aqueous solution and electrolysis line, PF-6.

The operations of jacketing, welding, and liquid metal bonding will be done in hood lines PF-17 and PF-25. These hood lines are also equipped for helium atmosphere operation. Every effort will be made to keep the inside of hood lines PF-17 and PF-25 at a low level of contamination so that finished pieces of radioactive fuel may be assembled and welded into uncontaminated jackets in these hoods. PF-17 and PF-25 are not connected to the highly radioactive central conveyor system. In spite of all efforts to keep the jackets clean, some contamination will from time to time be picked up on the fuel specimens that are to be jacketed. Hood line PF-18 has been provided with equipment for the decontamination of these jacketed specimens.

Hood lines PF-19, 21, 22, 23 and 24 are placed at the north side of the conveyor system for further fabrication, machining and assembly operations upon jacketed specimens. These hoods and the equipment housed within them will be kept uncontaminated.

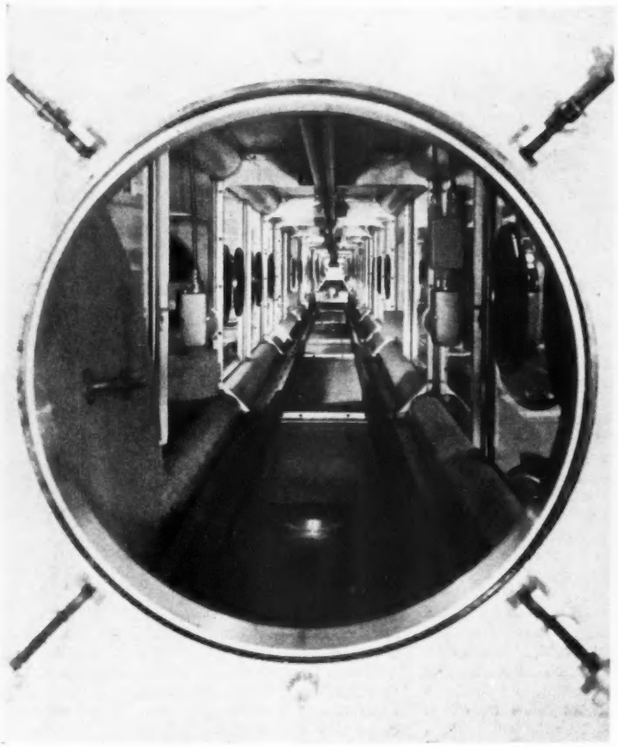
A study of existing commercial glove box designs and those used at other A.E.C. installations indicated that a new design would be required to house the very large and complicated equipment necessary for fuel fabrication. Designs were drawn up by the laboratory in accordance with the following requirements : (1) Modular standardised components should allow construction of hoods suitable for housing small delicate inspection equipment or large equipment such as rolling mills and extrusion presses. (2) The design must allow the enclosure of equipment up to 42in wide and yet provide complete access from both sides within the radius of the gloved arm of a human operator. (3) The design must allow modular variation in the vertical height of the glove boxes. (4) The glove boxes must have sufficient strength and rigidity to house safely the heavy operations of fabrication and should provide support for hoists and hanging certain items of equipment. (5) Provision should be made for housing and ventilation of contamination risk auxiliary equipment. (6) The glove boxes must be essentially gastight. (7) Maximum visibility of operations is required. (8) The materials of construction should be of low cost yet be resistant to atmospheric corrosion and subject to easy fabrication and welding.

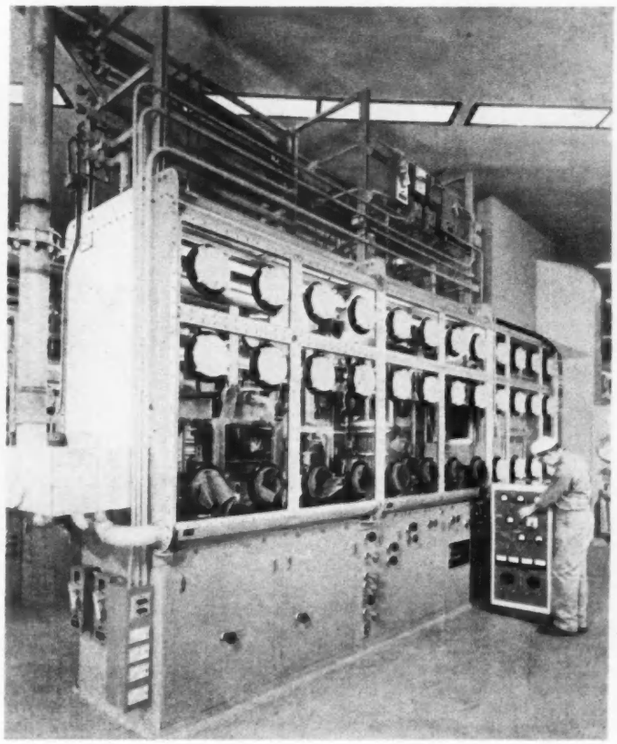
A system of glove boxes was developed to meet the requirements outlined above using specially designed aluminium alloy extrusions and a corner casting for the construction of rigid hood frames. Gasket grooves, ventilation ducts and the required structural shapes were formed by the extrusion process to minimise machining requirements. Heavy aluminium floor plates were used for most of the hoods although upon occasion steel plate floors were substituted. The end panels gasketed to flanges were of $\frac{1}{4}$in and $\frac{3}{8}$in



1. Conveyor
2. Introduction and removal
3. Machine shop
4. Electrolysis and aqueous solution
5. Weighing and inspection
6. Centrifugal casting
7. Ingot casting
8. Extrusion press
9. Rolling mill " A "
10. Plate shear
11. Wire fabrication
12. Press work
13. Future line
14. Future line
15. Welding and cladding
16. Decontamination
17. Rolling mill " B "
18. Work bench
19. Milling machine
20. Lathe
21. Plate shear
22. Liquid metal filling

Fig. 6—Floor plan of building showing the layout of the processing line with hood enclosures





Figs. 7 and 8—(Left) Conveyor line with chain-drawn dolly and photo-electric cells in foreground. (Right) Design of glovebox hoods on modular basis supported by the housings of lower contamination risk equipment

aluminium plate. The separator plates provided between the ends of the glove box modules were extended above and within the hood structure to support structures above and within the hoods. Running lengthwise through the hood frames are cavities forming ventilation ducts. Maximum tightness of the frames was achieved by the use of O-ring gaskets. This gasketing technique allowed metal-to-metal bolting of hood flanges and contributed materially to the rigidity and tightness of the structure.

The windows are of cast allyl plastic providing better optical properties, greater resistance to solvents and corrosive substances and a much higher degree of hardness and scratch resistance then methacrylate plastics. At the same time, the plastic windows possess a greater degree of flexibility than safety plate glass and are not subject to stress cracking.

The gloveports are high-impact phenolic plastic or cast aluminium rings inserted through holes in the window and gasketed to the window by means of moulded channel gaskets. Rubber gloves are fastened to these rings by means of rubber-backed aviation hose clamps. Provision is made for easy glove replacement. A rubber O-ring is snapped over each glove into a groove on the lip of the gloveport. This allows the clamp band to be removed, the cuff of the glove to be rolled back, and a new glove to be attached over the old glove. The old glove and O-ring can then be detached through the new glove and passed into the glove box without opening the system to the room air. The sealing door which separates each operating hood from the conveyor is somewhat similar to a large double-disc gate valve with a 19in square opening. The door bolts to the hood end plate and transition flange and seals to them by means of round section gaskets. A gastight seal is formed when the door is closed. The hood bases are constructed of structural steel angles, channels and T-sections. The foot of each base is provided with levelling screws. The base enclosures are of sheet metal constructed so that removable panels may be slipped into place and secured by spring-loaded turn latches.

The helium ventilating atmosphere for the glove boxes is drawn through two high-efficiency, fireproof filter chambers at the outer end of the hood line (Fig. 9). The filtered atmosphere passes through a filter housing and is piped to a ventilation duct running through the lower longitudinal hood member. It will be discharged into each glove box through slots just above the glove box floor. Adjustable valves are used to regulate the supply of ventilating gas to each module. The exhaust atmosphere is withdrawn from the hoods through slots equipped with adjustable covers on the upper longitudinal extrusions and discharged through a common exhaust duct to a 12in by 12in by 6in high-efficiency filter situated in a filter chamber on the conveyor.

Manually set dampers are used to regulate the flow through the hood line and to control the pressure within the hood line. Automatic controls are provided to isolate the glove box line from the helium gas recirculating system in case of an atmospheric break and to open emergency purge ventilation valves. A normal operating pressure of $-0{\cdot}6$in to $-0{\cdot}8$in water gauge with reference to the room pressure is maintained in the glove boxes. All filter changes are made from within the glove boxes to prevent spread of contamination to the room.

The safe operation of the glove box lines and the requirement of standby ventilation during filter changes made two completely separate stand-by ventilation systems necessary. It was determined early in the design studies that these should be capable of high volume purging of the hoods in case of breaks in the main hood barrier. Each of these systems consists of a pre-filter and final filter system in the fan loft and an exhauster capable of handling approximately 3000 cubic feet of air per minute. One stand-by system is connected by a 20in diameter duct to each hood line along the central conveyor through a 10in gastight, rubber-lined butterfly valve. The other stand-by system is connected to the clad work lines. These systems are opened when the pressure in any connected hood lines rises above the normal operating pressure. They provide a regulated flow of 500 cubic feet of air per minute through any opening formed in the hood line up to 6 square feet. If an opening larger than this is formed, a full 3000 cubic feet of air per minute is exhausted from the hood line. At the same time that one of the stand-by ventilation systems is opened, valves in the helium supply and return line are automatically closed so that the helium supply and return line are automatically closed and the helium recirculating system is not contaminated with air.

Processing Equipment

The selection and design of equipment for working with alpha radioactive materials in the fuel fabrication facility was governed by the following objectives : (1) To provide a versatile and flexible development laboratory and pilot plant. (2) To facilitate fabrication of a wide variety of research specimens required by the scientific programmes of the laboratory. (3) To provide capacity to produce experimental reactor fuel charges of the types required by various reactor programmes. Equipment of standard design was used if it was readily adapted to glove box enclosure and operation. Most equipment, however, was found to require some modification for gas-tight housing or for access to parts requiring maintenance or manipulation. Because

Fig. 9—Welding of inlet filter boxes for glovebox ventilating system of enclosure hoods

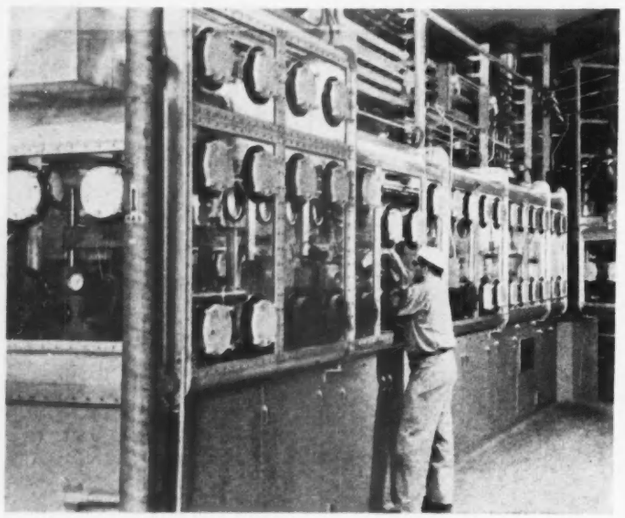


Fig. 10—Machine shop line with 50-ton hydraulic press and toolmaker's lathe

process flexibility was a major requirement, the facility was arranged in departments, where different kinds of work would be carried out, rather than as one long production line. Duplicate equipment was provided where required in the plutonium processing lines attached to the conveyor system and in the glove boxes provided for work upon jacketed materials.

(*A*) *Plutonium Fabrication Lines.*—(1) PF–3 : Conveyor. The conveyor consists of a single shuttle bogie riding upon rails. The rails enclose a continuous roller chain drive moving on sprocket wheels at either end of the conveyor. One of these wheels is powered by an electrically driven variable speed transmission, while the other serves as an idler and tensioner. Control is from a series of push-button stations at each operating hood line. As a safety precaution a light beam is projected down each side of the conveyor and photo-electric safety switches are provided to shut off the power and apply the brake to the conveyor drive in case the light beam is interrupted. This guards against shifting of the load in the conveyor or projection of an object or the gloved hand of an operator into the conveyor housing. A single transfer bogie was provided rather than moving belts or moving overhead hooks to eliminate the possibility of pieces of plutonium coming together to form a critical mass while passing through the conveyor. The conveyor mechanism was constructed by the Argonne National Laboratory. Transfer from the conveyor through the sealing doors of the operating hoods is accomplished by means of two-way slide transfer platforms.

(2) PF–4 : Introduction and Extraction Line. This line comprises three elevator platforms and a 4½kW dielectric sealing generator.

(3) PF–5 : Machine Shop Line (Fig. 10). This line comprises a 50-ton hydraulic press of special design, a 10in toolmaker's lathe converted to d.c. variable speed drive, a vertical milling and boring machine, a sheet metal shear of 24in by 14 gauge capacity, a universal milling tool grinder, and a milling machine converted to variable speed d.c. drive.

(4) PF–6 : Aqueous Solution Line. This line comprises a 4kW commercial rectifier with special control stations designed and built by the Argonne National Laboratory.

(5) PF–7 : Weighing and Inspection Lines (Fig. 13). In this area there are two 200 grammes grammatic balances, 1kg capacity, 0·2 milligramme sensitivity analytic balance, a 5kg capacity, 0·5 milligramme sensitivity balance with keyboard fractional weight and chain milligramme weights, a Rockwell hardness tester, and a "Federal" dial comparator, with space allowed for the future installation of special gauging and non-destructive testing equipment.

(6) PF–8 : Centrifugal Casting Line. The two vertical spindle, rotary table, vacuum centrifugal casting machines installed in this line are capable of melting 10kg of plutonium alloy at a vacuum of 0·0001mm of mercury and casting the alloy under centrifugal forces up to 80*g* in multiple permanent moulds. The high vacuum systems used in the facility employ diffusion pumps and mechanical pumps, and power for melting is provided by a 10,000 c/s induction heating generator.

(7) PF–9 : Ingot Casting Line. The ingot casting furnace consists of a bell jar vacuum chamber fitted with induction equipment capable of melting up to 10kg of alloy under a vacuum of 0·0001mm of mercury and casting it into water-cooled copper moulds. The gas pressure injection casting machine consists of a dual zone vacuum pressure furnace in which small diameter rods are cast in precision silica glass moulds coated with a refractory material. As many as

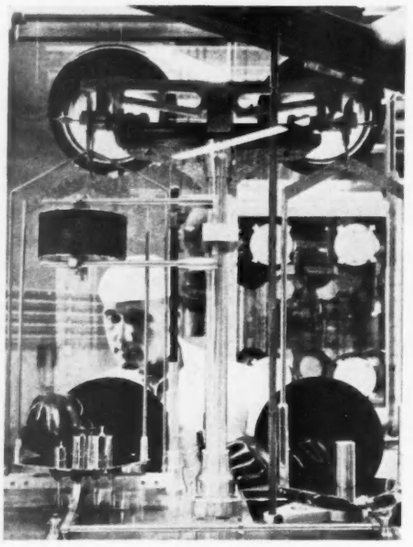


Fig. 13—Weighing and inspection line with 1kg analytical balance

130 of these moulds, closed at the upper end and open down, are suspended above the melting crucible. The crucible, heated by induction, is mounted on a vertically acting ram. A pair of thermal shield doors separate the melting zone from the mould heating zone. The furnace is evacuated by a diffusion pumping system to less than 0·0001mm of mercury. The moulds are brought to a temperature of approximately 400 deg. Cent., and the fuel alloy is melted under vacuum. The crucible is then caused to rise, immersing the open ends of the moulds. After a slight delay to allow quieting of the metal, a three-way vacuum pressure valve is operated, closing the vacuum pumping system from the furnace and opening a line to a pressure accumulator. The resulting pressure change causes the metal to fill the mould tubes, where it freezes. After cooling, the furnace is opened and the moulds are removed. The castings are stripped from the moulds, cropped to length and inspected. Usually no further processing is required.

(8) PF–10 : Extrusion Press Line. A blanked-off conveyor transition was left at PF–10 for the installation of an extrusion press. A 600-ton extrusion press is being built by the Sutton Engineering Company for delivery in August. The Argonne National Laboratory is designing the hooding, tool and billet heaters, handling equipment and a stretcher-straightener for it.

(9) PF–11 : Rolling Mill Line (Figs. 11 and

Fig. 11—Two-high four-high combination rolling mill before installation in hood enclosure

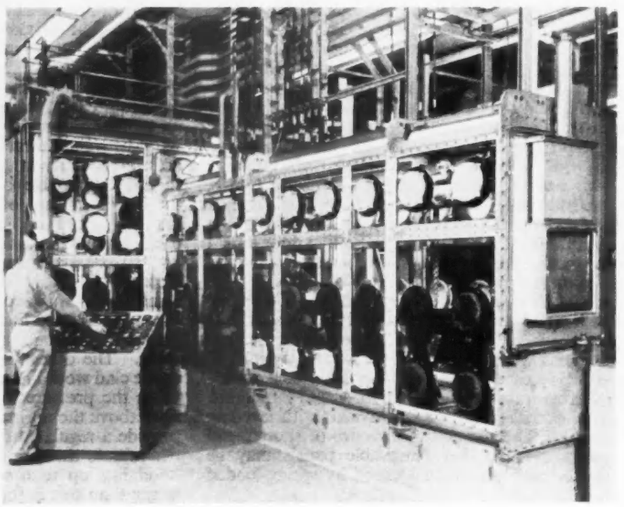


Fig. 12—Combination rolling mill after installation in "11" line with remote control operating station

12). This line comprises a two-high/four-high combination rolling mill with 10in diameter by 14in wide two-high work rolls and four-high backing rolls and 2½in diameter by 14in wide four-high work rolls. Roll changing is accomplished mechanically. The base of the mill forms the hood floor. Rolling mill feed and tensioning equipment and billet manipulators were specially designed to allow the complete remote manipulation of rods, shapes and flat items and the tensioning of the work as it is fed through the rolling mill. There is also a high vacuum rod-annealing furnace equipped to anneal billets at temperatures to 1200 deg. Cent. in a vacuum of 0·0001mm of mercury. A heating element chamber surrounding the furnace muffle is also kept under vacuum to equalise the pressure inside and outside the muffle, preventing its collapse and protecting the heating elements at high temperature.

(10) PF-12 : Plate Shear Line (Fig. 14) : This line was equipped with a specially designed ½in by 6ft capacity plate shear. The equipment was designed in such a manner that the end frames of the shear serve as divider frames between process hoods in the line, allowing the hoods to be bolted to the ends and between the end frames. This special design was necessary to keep the working parts of the shear within reach of the operator's arms. A heavy neoprene rubber expansion joint was provided to accommodate the differential thermal expansion of the steel shear frame and the aluminium hoods.

(11) PF-13 : Wire and Small Specimen Fabrication Line. The equipment in this line was provided to fabricate small wire and foil specimens of radio-active materials required in various scientific programmes of the laboratory. The line was equipped with the following machinery : a ½in capacity swaging machine, a high vacuum annealing furnace, a hydraulic draw bench, and a specially designed ⅛in capacity rotary swaging machine. The latter machine was modified to seal the spindle cavity and the frame housing. The machine was installed in a gap in the hood line with the front of the frame gasketed to one hood and flange and the rear of the spindle penetrating through a rotary seal in another hood. A crossed roller feeding device powered by a variable speed electrical transmission was mounted so that it may be retracted from the front of the swaging machine when not in use or when the dies are changed. Finally, this line also contains a two-high/four-high combination rolling mill at its extreme outer end. This machine has 5in diameter by 8in side two-high work rolls, 1½in diameter by 8in wide work rolls for four-high operation, and 5in diameter by 8in wide backing rolls for four-high operation. The mill was modified for application of the hood structure and provided with a manually operated slide-way for roll changing.

(12) PF-14 : Pressing and Powder Working Line. The main tool in this area is a 250-ton, down-acting, four-column press. The press is of special design to allow hooding to the lower platen and upper strain head by means of neoprene rubber compression packings. O-ring seals were provided to prevent leakage around the columns of the press. High vacuum equipment was also provided to evacuate a semi-portable vacuum-pressure furnace and to evacuate a high temperature bell jar sintering furnace. The hydraulic power unit of the press is housed below the hood line. The prefill tank and many of the valves are situated on top of the press above the hood line. The control panel is at the side of the hood line at operator's height. Because of the possibility of radio-active contamination, it was necessary to provide an enclosure extending from the sub-hood, covering the back of the control panel and the pipes, extending above the hood line and enclosing the prefill tank and overhead pipes and valves.

(13) PF-15 and PF-16 : Future Hood Lines. Provision was made along the central conveyor for future hood lines PF-15 and PF-16. All services were extended to capped valves for these hood lines. Transition enclosures and transfer platforms are provided with sealing doors and blank-off plates so that the two additional hood lines can be added.

B. Welding, Jacketing and Bonding.—The lines used for jacketing, welding and liquid metal bonding will be used both for the direct handling of alpha radio-active materials and for the handling of non-contaminated materials. The equipment in these hoods is maintained in a state essentially free from radio-activity so that the clean jacketing surfaces do not become contaminated. To avoid possible transfer of contamination through the conveyor, these hoods are not attached to the conveyor system.

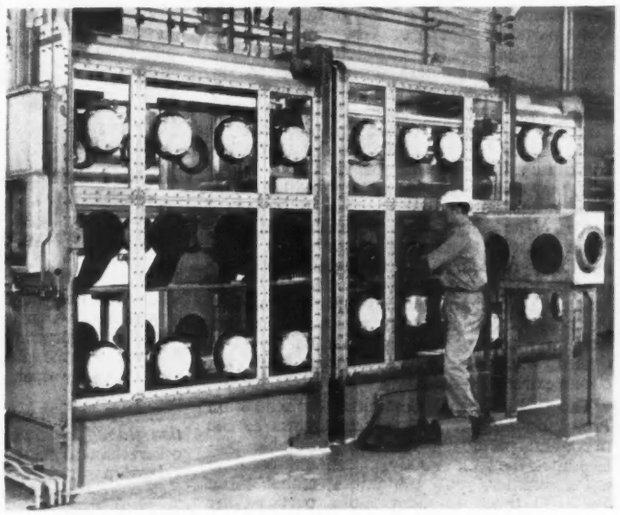


Fig. 14—½in / 6ft plate shear installed in "12" line of hood enclosure

(14) PF-17 : Welding and Jacketing. The swivel-mounted clamping press in this line consists of a structural steel frame holding four pneumatic cylinders operating a common water-cooled platen. The frame is carried upon swivels which allow rotation of the press through a 210 deg. arc. The assembly is mounted on a carriage which may be power-driven along tracks beneath a welding torch holder. This torch may be moved up and down and across the direction of the press movement, providing three degrees of motion between the clamping press and the welding head as well as providing rotation of the work. The work is clamped in a horizontal position. The press is then swivelled 90 deg. so that welding may be done. Upon completion of one longitudinal seam weld in a fuel element assembly, the press may be rotated 180 deg. so that the second weld may be completed without unclamping the assembly. The rotary positioner in this line is a modified milling machine indexing head equipped with a worm drive and power input shaft driven by a variable speed gear motor. Round work up to ⅛in diameter may be mounted in collets and rotated beneath a welding torch mounted either horizontally or vertically. Larger work may be mounted in a 10in lathe chuck.

(15) PF-25 : Liquid Metal Bonding Line. The equipment in this line consists of : a vacuum-pressure turret apparatus for filling spaces between the fuel rods and their metal containers with liquid sodium potassium alloys and for plugging and welding shut the fill openings, a small screw press for sodium extrusion, a vertical tube furnace for removing gas and for bonding, and auxiliary equipment below the hood line, including gas purifying apparatus and a high vacuum pumping system.

(16) PF-18 : Decontamination Hood Line. This line is equipped with a blast cleaning machine, electrolysis equipment and a vapour degreaser. Provision has been made for the installation of ultrasonic cleaning apparatus. The line is air-ventilated, and the air is exhausted through an alkali air washer situated in the basement.

(17) PF-19 : Rolling Mill Line "B." The mill equipment in this line is basically similar to that provided in PF-11, consisting of a 2½in and 10in by 14in two-high/four-high combination rolling mill equipped with auxiliary heating and tensioning equipment. An inert atmosphere muffle furnace is provided in place of the high vacuum annealing furnace installed in hood line PF-11. The muffle furnace was modified by the installation of a moving hearth mechanism. The hearth may be mechanically moved out of the furnace, becoming part of the rolling mill feed table on the forward pass. Upon reversal of the rolling mill, the work moves on to the hearth table and may be mechanically returned to the furnace.

(18) PF-20 : Station for Future Hooded Equipment. All of the normal hood line utilities have been brought to a point below the floor near the rolling mill, and a removable steel floor plate is provided beneath the floor covering at this point to allow the installation of a future free-standing hood line with a minimum of installation modifications.

(19) PF-21 : Work Bench Hood Lines. A low hood is provided here without installed equipment for temporary set-ups and hand work upon jacketed materials.

(20) PF-22 : Hooded Milling Machine. This line is equipped with a horizontal/vertical milling machine similar to that installed in Hood Line PF-5.

(21) PF-23 : Lathe Line. This five-module hood line contains a toolmaker's lathe, similar to the one in line PF-5.

(22) PF-24 : Plate Shear. This line contains a special ½in by 6ft plate shear which is identical to that in line PF-12.

(23) PF-26 : Negative Pressure Cooling System. Since the hooded enclosures are gas-tight, leakage of a conventional positive pressure water cooling system would result in flooding of the hoods with the attendant risk of nuclear accident, chemical explosion and spread of contamination. A negative pressure pumping system in which the cooling water is pumped at sub-atmospheric pressure is provided to prevent this occurrence. To establish a sub-atmospheric flow, a water jet eductor utilising the kinetic energy in one liquid flow circuit was used to cause flow in another circuit. Two turbine pumps supply the actuating liquid at approximately 100 lb per square inch pressure drop across two eductors. The eductors entrain approximately 13 gallons per minute of water each at 70 deg. Fah. and at a suction lift of 20 in mercury. The recirculated water is passed through a packaged liquid chiller capable of removing 250,000 B.Th.U. per hour from the coolant. Any entrained gases are vented to a filtered air exhaust system.

Safety Measures

The hazards of working with plutonium are a consequence of four properties of the element. (1) Plutonium has the property of criticality with respect to neutron multiplication and nuclear fission. (2) Plutonium is a strong emitter of alpha particles. (3) Under certain circumstances, plutonium may constitute a radiation hazard. (4) In some forms, plutonium is pyrophoric, combining spontaneously and energetically with oxygen and producing sufficient heat to ignite combustible materials in its environment. The Fuel Fabrication Facility is designed to obtain maximum control over these four hazardous properties.

1. *Criticality.*—Critical mass is a characteristic all nuclear fuels. It may be defined as the of minimum mass of fissionable isotope required under a given set of conditions to initiate a nuclear chain reaction. The term is somewhat misleading in that criticality is not a factor of

mass alone, but is influenced by shape, dispersion, energy of the neutrons, kinds of materials in which the fissionable isotopes are dispersed, and materials surrounding the fissionable material which may reflect neutrons. The three fissionable isotopes of importance as reactor fuels are U^{235}, U^{233} and Pu^{239}. Two concepts of safety are used in evaluating work with critical materials. One is the concept of "always safe mass." The second is the concept of "always safe geometry." The always safe mass is the amount of fissionable isotope which, regardless of shape, disperson, moderation or reflection, cannot sustain a nuclear chain reaction. Work with quantities below the always safe mass provides the maximum of protection for the workers, provided, of course, that two or more such masses are not brought close enough together to form a critical system. Since much of the processing of uranium and plutonium is done in ordinary light water solutions, which is both an excellent moderator and reflector of neutrons, the always safe mass is a concept of great practical importance.

The plutonium as received at the facility contains other isotopes of plutonium than Pu^{239} and impurities. For this "commercial" plutonium, 300 grammes is usually considered the always safe mass below which criticality does not present a problem. It is possible and often necessary to work with several thousand grammes of plutonium, provided that attention is paid to the materials in which the plutonium is contained, to how the plutonium is dispersed, and to the geometric shape of the plutonium. This is the concept of always safe geometry.

It is important to guard against conditions under which the system might become critical. For instance, 3000 grammes of solid "commercial" plutonium is considered safe as a single piece even though it is accidentally flooded with water. Dispersion in a moderating medium would cause the same amount of plutonium to be supercritical. If a larger piece of plutonium were handled, flooding might cause a chain reaction. Flooding with water provides neutron reflection and must be avoided where substantial quantities of plutonium are processed or machined.

It is possible to work with pieces of plutonium metal which in a compact state would be supercritical, provided that attention is paid to their geometry. Thus, a $\frac{1}{16}$in plutonium plate of any size or a 1·4in diameter rod of any length is safe even though the total mass is many times the always safe mass. These considerations apply to isolated masses. Obviously, plutonium plates or rods cannot be stacked without violating the principle of always safe geometry. The effect of interaction between safe masses spaced some distance apart must also be considered, particularly when a neutron slowing or moderating material might be placed between the masses. Storage vaults present a special problem in this respect, since many shapes and sizes of pieces, and dispersions of plutonium in other materials, must be stored.

It is conceivable that the moderating effect of the body of a human worker entering the vault might moderate or reflect enough neutrons to cause criticality. This is guarded against by arranging the vault stacks in cubicles and by limiting the quantity of plutonium stored in any cubicle. The spacing between stacks of shelves is also calculated so that if the shelves are loaded to capacity, the body of the custodian does not cause a nuclear chain reaction. The number of persons allowed at any time to be in a vault may also be limited. Special care must be taken so that vault shelves cannot collapse or be tipped against one another.

Fire in a vault presents a serious problem. Firemen must be prevented from flooding the vault with water, both for reasons of criticality and because of the violent chemical interaction between water and many plutonium alloys. Neutron absorbers are sometimes used in vaults to reduce the flooding hazard potential.

Since all persons working with fissionable materials are not nuclear physicists experienced in the problems of criticality, the practice is to prepare a careful analysis of all operations exceeding the always safe mass of fissionable material. A detailed programme of work to be done is planned in advance. A report is prepared showing how the work will flow, how much plutonium will be at a given place at a given time, and how the fuel being studied or manufactured will be composed. Internal moderators and neutron poisons are described in the report. The physical arrangement of the equipment and materials of construction for special laboratory equipment such as crucibles are also described. So that possible interactions may be studied, a motion study and transportation plan are essential when many items are to be processed. Often the plan is carefully rehearsed, using inert materials. The reports and rehearsals are carefully studied by a committee of scientists and engineers experienced in the analysis of criticality problems. Only after their approval is received can the work begin. Unfortunately, there is no effective or practical instrumentation for monitoring approaching criticality in a processing plant. Close administrative control is necessary over all processes and personnel to see that safe procedures are followed and that careless habits do not develop.

2. *Protection Against Alpha Particle Emitters.*—Plutonium emits three forms of radioactivity: alpha particles, gamma or X-rays and neutrons. Of these, alpha particle emission, because of its intensity, is of greatest consequence. Alpha particles emitted by plutonium have an energy of 5·15 MeV and a mean range in air of 3·68cm. They are stopped by a thin film of plastics or metal foil or by human skin and thus do not constitute a hazard as external radiation. However, they are very heavy particles and over their short range do extreme damage in biological tissues. The danger from plutonium and other alpha particle emitters comes from their possibility of being inhaled, ingested or introduced through cuts or skin lesions. Unfortunately, plutonium is not completely eliminated from the body by natural processes and becomes fixed in tissues of the body, particularly bone tissues, where its strongly ionising radiation causes extreme damage.

The U.S. National Committee for Radiation Protection has set 0·13 microgrammes as the maximum permissible limit of insoluble plutonium in the human body. Uranium, too, is an alpha emitter, but plutonium emits about 5,000,000 times as many alpha particles per gramme as does uranium–238 or thorium. So while uranium–238 or thorium can be handled with about the same degree of precaution as any toxic metal, plutonium must be handled as though it were thousands of times more toxic than the most dangerous industrial poisons. In ordinary moist air, plutonium tends to form a finely divided, loosely held oxide which has a remarkable ability to pass into the air and to remain airborne. The U.S. National Committee on Radiation Protection has established a maximum permissible limit of $2{\cdot}0\times10^{-12}$ microcuries of plutonium per millimetre of air.

From the very low maximum permissible limit of plutonium in air, it is evident that unless the plutonium is contained in a gastight container, or fixed in a non-oxidising alloy, it is necessary completely to separate the atmosphere exposed to the plutonium from the air breathed by the operators. This is done in the present installation by enclosing the work spaces and equipment in glove box enclosures. Because the inside of these enclosures becomes very highly contaminated, it is necessary when designing this equipment to achieve a high degree of tightness. The associated ductwork, piping, electrical lines and process equipment which penetrate the walls of the enclosures must be made gastight to the outside. In the fuel fabrication plant, a leakage rate of 0·02 cubic foot of gas per hour per 100 cubic feet of enclosed space at a negative pressure of 2in water gauge was the maximum allowed. Leaks were hunted using helium-sensitive mass spectrometer leak detectors.

A second method of controlling the leakage of plutonium contamination from the enclosure is to maintain the inside of the glove box at a negative pressure with respect to the room atmosphere. About 0·8in water gauge is the maximum differential pressure recommended because above this figure the gloves tend to inflate on the hands of human operators, making manipulation very clumsy. Customarily, two pairs of rubber gloves are worn by the operator in the fuel fabrication plant. A heavy synthetic rubber glove is clamped to a port in the wall of the glove box. The operator wears thin surgical gloves on his hands to afford secondary protection in case the heavy gloves become snagged or cut. Great care is taken to prevent penetration of the gloves by

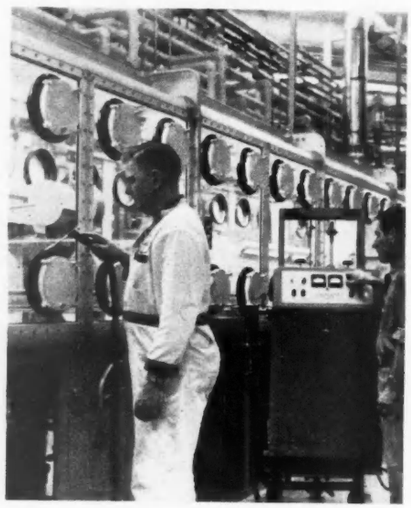


Fig. 15—Leak inspection of glovebox enclosures using a helium-sensitive mass spectrometer leak detector

sharp or hot objects. This is particularly important in a metals fabricating plant where many high temperature operations must be performed. For the sake of safety as well as production, as many operations as possible are done mechanically.

3. *X-Rays, Gamma Rays and Neutron Radiation from Plutonium.*—Until recently, radiation other than alpha emission has not been considered a serious hazard from plutonium. In general, the plutonium isotopes are rather weak sources of soft X-rays. With increase in reactor exposure, and subsequent increase in the percentage of higher plutonium isotopes which decay into radioactive daughter products, the amount of gamma and X-rays has tended to increase. In some cases it is now necessary to limit hand exposure or to wear gloves loaded with lead in order to stay within maximum permissible limits of exposure.

The neutron problem is a consequence of the alpha-neutron reaction with the elements beryllium, boron, lithium, nitrogen, fluorine, sodium, magnesium or aluminium. The alpha-neutron reaction with fluorine may produce a sufficient intensity of neutrons to be a consideration in the chemical processing of plutonium. An alloy of plutonium with beryllium is a commonly used neutron source. Some consideration has to be given to the neutron problem in the preparation of alloys and in the selection of crucible materials in which to heat plutonium.

4. *Control of Pyrophoricity and Oxidation.*—An additional consideration in handling and fabricating plutonium and its alloys is the fact that under certain conditions they constitute a considerable fire hazard. This hazard is compounded by the criticality and radioactivity problems, making a major fire in a plutonium facility extremely difficult to control. Fairly large pieces of unalloyed plutonium metal may be handled with reasonable safety. The danger of fire results from (1) finely divided materials such as turnings and powders, (2) unstable and mechanically sensitive hydrides (compounds which may form in moist atmospheres), (3) spontaneously pyrophoric alloys and intermetallic compounds, and (4) spontaneous ignition of impure metallic residues, such as partially oxidised crucible skulls.

Plutonium, like other materials, possesses an ignition temperature below which it oxidises so slowly that the heat of oxidation does not maintain combustion and above which oxidation progresses very rapidly. The ignition tempera-

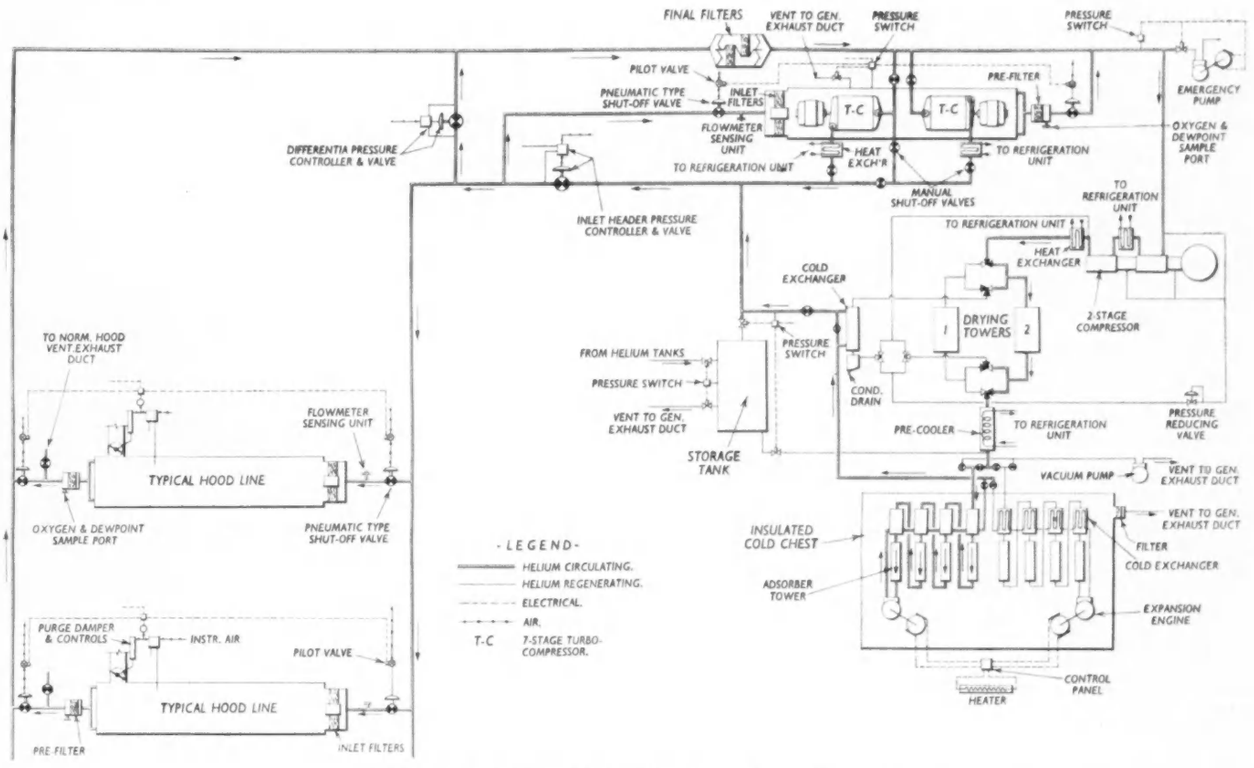


Fig. 16—Flow diagram of helium atmosphere system in hood enclosures

ture varies with the form and composition of the plutonium-containing material. Many metallurgical operations with plutonium, such as melting, heat treating and hot working, must be carried out at temperatures above the ignition temperature. Provision must be made to exclude oxygen when such operations are performed. This is conventionally done in furnaces or containers which are evacuated or flooded with inert gas. Occasionally, in the past, isolated gloveboxes have been provided with a protective inert gas atmosphere. Since 1954, a small plutonium research laboratory has been in operation at Argonne National Laboratory incorporating a system of gas-tight interconnecting gloveboxes which are supplied with a continuously recirculated and purified helium atmosphere. The special techniques developed for this system provided an unequalled record of contamination safety. These techniques so successfully minimised the hazards of fire and oxidation that the requirement of an inert atmosphere was made for the plutonium fuel fabrication plant.

Besides its inertness, helium possesses a number of characteristics which make it especially useful in a plutonium experimental facility. These are : (1) Helium has a high heat capacity and excellent heat transfer characteristics. (2) The gas is amenable to purification by regenerative physical means. (3) Highly sensitive techniques are available for determining leaks in a helium-filled system.

The helium atmosphere system in the building consists of two circuits : (*a*) a recirculating circuit, handling either 1000 or 2000 cubic feet of gas per minute, depending on how it is set up, and (*b*) a regenerative purifying circuit handling approximately 100 cubic feet of gas per minute. The fuel fabrication plant utilises nearly 10,000 cubic feet of helium gas kept constantly in motion through its process enclosure system. Since helium is an extremely scarce national resource, care was taken in designing and building the process enclosures to minimise leakage of this gas. The helium is pumped at less than atmospheric pressure so that leakage will be into the system rather than out of it. This leakage of air is estimated to be 0·01 per cent of the gas in the system per hour. The regenerative purifying circuit was designed to remove eight to ten times this amount.

A slight loss of helium will occur when objects are put into the process hoods or taken out. The central "conveyorised" arrangement of process enclosures in the building minimises the number of times objects are introduced or removed. Loss of helium from the plant is estimated at 200 to 400 cubic feet per week of operation, depending partly on this introduction and removal. The pumping of helium gas presents several problems not encountered with heavier gases. Helium is approximately one-seventh as heavy as air, and it therefore cannot be pumped by a standard centrifugal blower designed for air. The recirculating blowers of the fuel fabrication plant are seven-stage turbo-compressors which will handle approximately 1000 cubic feet per minute at a pressure head of about $\frac{1}{4}$ lb per square inch. These units are used with an aftercooler.

Cross-over connections and valves are provided so that : (1) one blower may be used while the other stands by, (2) both blowers may be used in parallel to move up to 2000 cubic feet per minute of gas, or (3) both blowers may be used in series, with the aftercooler of the first becoming an intercooler between the two blowers. When used in series, the blowers can produce approximately 1·15 lb per square inch differential pressure at 1000 cubic feet per minute delivery. In addition to the 12in by 12in by 6in high-efficiency filters provided at each hood line, two 24in by 24in by 12in high-efficiency filters are provided in the main return line to refilter all of the gas in the recirculating system before it reaches the turbo-compressors.

In the repurifying circuit, a two-stage sealed compressor raises the helium pressure to 165 lb per square inch. The heat of compression in two stages will raise the temperature of the gas to approximately 420 deg. Cent., so that an intercooler and aftercooler are provided to bring the gas down to room temperature. The cooled helium is then passed through drying towers, where almost all moisture is removed. After passing through the drying towers, the gas is piped to a cold exchanger where it is cooled to −40 deg. Fah. by evaporation of freon gas. The helium is then passed through four activated carbon towers in series. Provision has been made to cool the gas from the carbon towers to liquid nitrogen temperatures and to pass it countercurrently through gas-to-gas heat exchangers situated between the carbon towers. This provides the necessary low temperatures required for start-up operations with impure gas. Regeneration of the activated carbon towers is accomplished by valving the main flow of helium to an alternate set of carbon towers and then evacuating the original towers, thereby clearing them of oxygen. Provision is made to pipe a small flow of hot helium to the towers from the compressor when hot regeneration or defrosting is required.

A plutonium metal fire cannot be fought with water because of the problem of criticality and because water in contact with hot reactive metals releases large amounts of hydrogen which can result in a secondary explosion. Carbon dioxide is of doubtful value in fighting metal fires. Exclusion of air seems to be the only effective fire-fighting procedure which has been developed to date. Dry extinguishers, such as powdered carbon and powdered silica, have been recommended. Because of the alpha radioactivity hazard, fire-fighters must be equipped with suitable protective clothing and supplied with air masks—preferably "frogman" suits. Because fire is a serious hazard in a plutonium factory, an effective fire warning device was considered essential in each glove-box line of the fuel fabrication factory. A pneumatic temperature rise rate detector developed by the Walter Kidde Corporation was selected. The system installed consists of thin-wall copper tubing passing in a loop below the ceiling of each glove-box line through seals in the ends of the line. The tubing then passes in a loop through the housing below the glove-boxes. Gas in the tubing is allowed to escape at a calibrated rate as it expands under normal changes in temperature. In case of fire, the expansion of gas is so rapid that it cannot escape the tubing ; the increased pressure closes a bellows switch which sounds the fire alarm.

Storage vaults for radioactive materials are provided with tubing on the underside of each alternate shelf as well as below the ceiling of each vault. The system is also extended to laboratory rooms and offices of the entire building. The fire signal operates alarms throughout the building ; panel indicator lights show the location of the fire. Relays transmit signals to the Argonne plant security and fire protection departments where the location of the fire is indicated by a code printing machine.

The new plant is being operated by the metallurgy division of the Argonne National Laboratory, under the direction of Dr. Frank G. Foote, and was designed by a group of engineers under the direction of Arthur B. Shuck.

Personal and Business

Appointments

MR. P. WRIGHT has been appointed a director of Buckley and Taylor, Ltd.

MR. JAMES L. RITCHIE has been appointed sales director of Holman Brothers, Ltd.

MR. R. PATRICK LISTER has been appointed home sales director of Coventry Climax Engines, Ltd.

DR. A. G. J. BUCKLE has been appointed technical director of Technicon Instruments Company, Ltd.

MR. FRANK L. WESTMACOTT has been appointed sales manager of Toledo Woodhead Springs, Ltd.

MR. DENNIS WRIGHT has been appointed sales manager (tractors) of Road Machines (Sales), Ltd.

MR. E. N. EVANS, M.I.E.E., has been appointed to the board of directors of Blackstone and Co., Ltd.

MR. W. CUSWORTH has been appointed a director of the Brightside Foundry and Engineering Company, Ltd.

MR. P. F. SHUTE has been appointed divisional signal engineer, Manchester, London Midland Region, British Railways.

MR. J. P. ELLIOTT, secretary and director of Davey, Paxman and Co., Ltd., has been appointed assistant managing director of the company.

LONDON MIDLAND REGION, British Railways, states that Mr. W. F. Beatty, district engineer, Crewe, has been appointed new works officer, London.

LONDON MIDLAND REGION, British Railways, announces that Mr. A. L. Owen, A.M.I.C.E., district engineer, Manchester, has been appointed new works officer, Manchester.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY has appointed Mr. J. B. Adams to be director of a new establishment to deal with controlled thermo-nuclear research.

MUIR ROBB GROUP, Ltd., has announced that Mr. J. P. Featherstone has been appointed to its board of directors and also to the board of its leading subsidiary, Road Machines (Drayton), Ltd.

MR. O. R. SMART, principal assistant to general manager, Eastern Region, British Railways, has been appointed supplies and contracts manager, Eastern Region, with headquarters at King's Cross.

LONDON TRANSPORT announces that Mr. R. W. Nesbitt has been appointed principal executive assistant, with the title of production engineer, in the department of the chief mechanical engineer (railways).

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the appointment of Mr. E. J. Scotcher, A.M.I.E.E., as factory superintendent at its Huyton Works. Mr. H. Brown has been appointed traffic manager.

LONDON MIDLAND REGION, British Railways, states that Mr. I. C. Forsyth, works manager, Crewe Locomotive Works, has been appointed mechanical and electrical engineer (workshops) in the C.M. and E.E. department, Derby.

SIEMENS EDISON SWAN, Ltd., announces that Mr. J. Petrie has been appointed district office manager of Dundee and Aberdeen following the retirement of Mr. W. Gillespie. Mr. J. McGregor has succeeded Mr. E. J. Fairweather, who has retired, as district office manager at Edinburgh.

MR. O. S. JOHNSON, A.M.I.E.E., has been appointed to take charge of the high-tension section of the research laboratories of W. T. Henley's Telegraph Works Company, Ltd., in succession to Dr. B. F. Salvage, A.M.I.E.E., who is taking up an appointment as lecturer at Leeds University.

MR. L. R. P. PUGH, director and secretary of Guest Keen Iron and Steel Company, Ltd., has been appointed assistant managing director and has been succeeded as secretary by Mr. C. F. Pagnamenta. Mr. B. W. John, assistant secretary, has succeeded Mr. Pagnamenta as chief accountant.

MR. JOHN W. HAMMON has been appointed sales manager of the agricultural and industrial engine division of the Villiers Group of Companies. Mr. John V. Ridley has been made personal assistant to Mr. Geoffrey Jones, joint managing director, on all aspects involving Villiers and J.A.P. agricultural and industrial engine sales.

BRAYHEAD, Ltd., announces that Mr. W. Murphy, the former managing director and Mr. C. Bone, secretary, have left the Brayhead Group of Companies. Mr. R. A. Palfreyman has been appointed chairman of the Group; Mr. F. J. Pusey and Mr. H. T. Mote will act as joint managing directors. Mr. P. Myers and Mr. H. R. Holland have been appointed directors, and Mr. A. Bond, secretary.

THE BIRFIELD GROUP announces that Mr. G. W. M. Lush has relinquished his appointment as managing director of Birfield Engineering, Ltd., but that the company continues under the direction of Mr. D. Bastow and Mr. E. J. Rabson as full time executive directors. Mr. J. E. Hooper has resigned as director and secretary of Birfield Engineering, Ltd., and has been succeeded by Mr. N. Manders.

MR. R. F. CAMPBELL, A.M.I.E.E., has been appointed generation-engineer, Midlands Division, of the Central Electricity Generating Board, in succession to Mr. H. Bancroft, who has been transferred to the East Midlands Division. Mr. T. Howard, A.M.I.E.E., formerly deputy station superintendent at Hams Hall "B" power station, has been appointed station superintendent of Nechells "A" and "B" power stations.

MR. S. E. BOLTON has been appointed to a newly created post of assistant general manager, export sales, for the English Electric Company, Ltd. Three new appointments have been made in the English Electric Company's export organisation: Mr. J. F. Herbert has been appointed general manager export sales; Mr. S. E. Bolton, assistant general manager export sales, and Mr. S. W. J. Butler, manager of a new overseas factories department.

THE BRITISH TRANSPORT COMMISSION announces that Mr. J. H. Fraser, chief signal engineer of the British Railways Central Staff at Commission headquarters, will retire on Septemver 12. He will be succeeded by Mr. A. W. Woodbridge, signal engineer, Western Region. Mr. C. S. McLeod, regional establishment and staff officer, Eastern Region, British Railways, has been apponted director of industrial relations in the manpower adviser's department at Commission headquarters, in succession to Mr. C. H. Brazier, who has retired.

Business Announcements

WOODALL-DUCKHAM, Ltd., has acquired the whole of the share capital of Nordac, Ltd.

MR. R. H. POWELL has relinquished his appointments with the Griffin and George Groups of Companies.

HARDY SPICER, Ltd., has transferred to new premises at Chester Road, Erdington, Birmingham, 24 (telephone, Erdington 2191).

HOLMAN BROTHERS, Ltd., Camborne, Cornwall, has announced the formation of a Spanish manufacturing subsidiary company, Holman Iberica S.A.

FERRANTI, Ltd., Hollinwood, Lancs, states that production of the single-phase FMm and polyphase FMx meters has been started in its Dundee factory.

THE U.A.M. GROUP announces that the name of its exports subsidiary, Universal Asbestos (Overseas), Ltd., has been changed to U.A.M. Overseas, Ltd.

INTERLAS, Ltd., 232, Bromham Road, Bedford, has been formed to import and distribute exclusive welding plant and accessories throughout the United Kingdom.

THE CVA GROUP has opened executive offices at 79, Davies Street, London, W.1 (telephone, Mayfair 3051/2). There will be no sales service at this address.

MR. R. Y. SANDERS, deputy commercial and development adviser to the Electricity Council, has decided, for health reasons, to retire from the post on September 30.

SANDERS AND FORSTER, Ltd., states that its standard building department has been transferred from Barking to Walton House, Warton Road, London, E.15 (telephone, Maryland 3228).

THE MITCHELL CONSTRUCTION COMPANY, Ltd., of Peterborough, announces that it has acquired the building and civil engineering contracting business of Arthur Waterman, Ltd., of Leeds.

PERCY BILTON, Ltd., civil engineers and building contractors, has moved from Park Street, London, W.1, to Bilton House, 54-58, Uxbridge Road, London, W.5 (telephone, Ealing 7777).

TORVAC, Ltd., Histon, Cambridge, has been formed to advise on design and manufacture of special vacuum equipment for use in the high, medium or rough ranges, with special emphasis on metallurgical equipment and batch and continuous metallising.

DISTINGTON ENGINEERING COMPANY, Ltd., a subsidiary of The United Steel Companies, Ltd., has established a continuous casting division which will specialise in the design and manufacture of continuous casting plants for both ferrous and non-ferrous metals.

CHARLES H. WINDSCHUEGL, Ltd., 1, Leadenhall Street, London, E.C.3, has been appointed sole U.K. agent for four "Lusin" mould release agents manufactured by Large and Seidel, of Nuernberg.

CORY BROTHERS AND CO., Ltd., a member of the Powell Duffryn Group, has acquired the share capital of MacCleaster Chemical Company, Ltd., 8, Great Tower Street, London, E.C.3 (telephone, Mansion House 4555).

NASH AND THOMPSON, Ltd., Chessington, Surrey, announces that it has concluded arrangements for the marketing of the G.K.N. micro-hardness tester, manufactured by Associated Automation, Ltd., Dudden Hill Lane, London, N.W.10.

LANCASHIRE DYNAMO GROUP states that the address of its Newcastle office has been changed to Lancashire Dynamo Group Sales, Ltd., Eagle Star House, 32-34, Mosley Street, Newcastle upon Tyne, 1 (telephone, Newcastle 28621 and 29736).

UNIVERSAL-MATTHEY PRODUCTS, Ltd., an associate company of Johnson, Matthey and Co., Ltd., has formed a subsidiary company in Cologne, Universal-Matthey Products (Deutschland) G.m.b.H., for the manufacture of platinum catalysts.

BTR INDUSTRIES, Ltd., announces that it has concluded an agreement with Gewerkschaft Keramchemie of Siershahn Westerwald, Germany, to act as its U.K. representatives for the design, supply and erection of chemical and corrosion-resisting plant and equipment.

SEMTEX, Ltd., 19-20, Berners Street, London, W.1, has concluded an agreement with Morris de Leval, Ltd., whereby the Semtex Company has been appointed sole distributor in the United Kingdom of "Synthanite," a special type of synthetic anhydrite, for flooring and roofing purposes.

COMPOFLEX COMPANY, Ltd., has announced the opening of a London warehouse at Angel House, Pentonville Road, London, N.1 (telephone, Terminus 0533-4). The company will in future undertake the marketing in the U.K. and Northern Ireland of certain long length hoses made by the Pirelli Company of Milan.

ROCOL, Ltd., Swillington, near Leeds, has announced that an agreement has been signed with the Societé Nouvelle des Huiles Minerales of France, for the manufacture of Rocol molybdenised and other specialised industrial and motor lubricants in France and for their distribution throughout the European Common Market area.

THE BIRFIELD GROUP announces that it has transferred the production and administration of "Birflo" controls to Laycock Engineering, Ltd., Victoria Works, Millhouses, Sheffield, 8 (telephone, Sheffield 74411). It also announces that the entire offices and works of Birfield Engineering, Ltd., have now been concentrated in part of the new factory of Hardy Spicer, Ltd., Chester Road, Erdington, Birmingham, 24 (telephone, Erdington 2191).

AMPEX CORPORATION, Professional Products Division, Redwood City, California, announces that it has been appointed sole authorised distributor in the United States of Marconi television cameras, television equipment and broadcasting equipment. Under the terms of the arrangement Ampex will also be the authorised distributor in the United States for the television camera tubes manufactured by the English Electric Valve Company, Ltd.

MOREHOUSE INTERNATIONAL OF LOS ANGELES, GUEST INDUSTRIALS, Ltd., of London, and DURHAM RAW MATERIALS, Ltd., of London, announce a change in the agency arrangements for the sale of Morehouse Mills and Cowles dissolvers in the United Kingdom and Eire. Guest Industrials have relinquished the agency in favour of Durham Raw Materials, Ltd., 1-4, Great Tower Street, London, E.C.3, which will handle it through its chemical engineering division.

Contracts

F. G. MINTER, Ltd., has been awarded a contract by the B.B.C. for the formation and completion of technical and special areas in the new building, Nos. 10-22, Portland Place, London, W.1, which is to form the extension to Broadcasting House.

HEAD WRIGHTSON COLLIERY ENGINEERING, Ltd., has been awarded a contract by the National Coal Board, West Midlands Division, for a new coal preparation plant at Wolstanton Colliery, Stoke-on-Trent. The plant, which will cost approximately £1,250,000, has been designed to handle run-of-mine coal at the rate of over 700 tons per hour and produce two qualities of coal. This contract forms part of the general reconstruction programme at this colliery.

MARCO CONVEYOR AND ENGINEERING COMPANY, Ltd., of London, in conjunction with the CONSTRUCTIONAL ENGINEERING COMPANY, Ltd., of Birmingham, has obtained an order from Yugoslavia for the supply of a complete mechanised foundry for the production of tractor engines. The whole of this equipment will be designed in Great Britain, but some portions of the steelwork will be fabricated in Yugoslavia. The value of the equipment to be manufactured in this country is £73,000.

CONSTRUCTORS JOHN BROWN, Ltd., has been awarded a contract of the value of approximately £2,500,000 for the supply of a sugar factory at Kavar in Iran for the Sherkat Shami Ghande Pars Company. For this project A. F. Craig and Co., of Paisley, will supply equipment capable of processing 1000 tons of sugar beet per day, with allowance for eventual expansion to 1500 tons per day. Work will start immediately and the factory is due for completion by early 1961. The contract provides for the training of Iranian personnel in the operation and maintenance of the plant.

HEENAN AND FROUDE, Ltd., of Worcester, has been awarded a contract valued at £250,000 for the construction of a new refuse disposal plant for the Salvage Department of the City of Birmingham. The new plant, which will be built on a site adjoining the City's old Lifford Works, will have a disposal capacity of 300 tons of domestic refuse in sixteen hours by screening, salvage and incineration. This is the fifth major installation of this kind to be built by Heenan and Froude, Ltd. for the City of Birmingham, the company having been the main contractors for four previous plants, built between 1924 and 1934.

TAYLOR-WOODROW CONSTRUCTION, Ltd., has received a contract from the Minister of Transport and Civil Aviation, costing £741,807, for a by-pass nearly two miles long on the A1 route at the village of Wentbridge in the West Riding. It will have dual 24ft carriageways, a 15ft wide central reservation and two 12ft verges. The scheme involves construction of a new bridge 470ft long over the River Went, which it will cross about 100ft above the valley floor. Another bridge to carry Went Edge road over the by-pass will also be built. The West Riding of Yorkshire County Surveyor prepared the scheme, which it is expected will be completed by the Spring of 1961.

Miscellanea

LIQUID METAL ANODIC UNIT.—We are informed by Southern Metalife, Ltd., that it is now producing a solid Metalife liquid metal anodic unit, which is designed to give protection against corrosion. The unit, which is self-supporting, is intended for water tanks ranging from 100 to 1500 gallons capacity, and will give from eight to twelve years' service, depending upon the size of the tank, the type of water, and the temperature.

EXHIBITION SHIP.—We are informed by Oceanwise Exhibits, Ltd., 22, Half Moon Street, London, W.1, that it proposes to convert a light aircraft carrier to an exhibition ship to act as a floating showroom for the display of the products of British industry. Planning is initially on the basis of three years' operation.

CATALYSED COATINGS.—Cold setting catalysed coatings for a variety of industrial uses are now being marketed by Jenson and Nicholson, Ltd., of Stratford, London. These coatings are stated to dry effectively at temperatures down to 50 deg. Fah., and at temperatures down to this level to be touch dry within 90 minutes and hard dry within eight hours. These air-drying coatings are epoxy resin based industrial finishes and are applied by brush or spray. They adhere to cement, plaster, wood, glass, all metals and most painted surfaces. Such coatings have hardness and toughness combined with flexibility to resist mechanical damage, whilst being resistant to alkalis, acids, caustic solutions and organic solvents.

COMPONENT CONTAINERS AND SHELVES FOR STORES. A design of container and shelf known as the "Fix" system has been introduced by Kimbell Machine Tools, Ltd., 4, South Lambeth Place, London, S.W.8, for use in stores for small and medium size components. This system uses three sizes of interlocking shelves which can be assembled in any required number to take six sizes of sliding containers which range between 28in by 19in by 12in to 3½in by 4in by 2in. These containers have an inclined open front which facilitates removal of individual components by a storekeeper and enables a visual check to be maintained over the number of components in store. When removed from the shelves the containers nest on top of each other to facilitate stacking, and they can also be fitted with covers for transport purposes. To allow the storage of small delicate components the smaller sizes of containers are made in plastic materials as well as sheet metal.

HINKLEY POINT CAISSON.—In the emergency issue of THE ENGINEER of July 31 last, we described the caisson used at Hinkley Point nuclear power station to construct the cooling water intake. We did not mention in that description that the structural steelwork for the caisson—about 404 tons of it, including the temporary decks and false bottom steelwork, the spuds, spud collars, jacking towers, crossheads and operating platforms—was supplied and erected by the United Steel Structural Company, Ltd. Machining of the crossheads and link plates was done by G. R. Turner, Ltd., of Nottingham, and Sheepbridge Equipment, Ltd., of Chesterfield, respectively. The steel sheet piling was supplied by the Appleby Frodingham Steel Company.

SCREW THREAD STANDARDS GUIDE.—A very useful addition to the literature on screw threads has just been published by W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford, under the title of "The Robertson Guide to World Screw Thread Standards." For this publication the firm has collected the screw thread standards of the world and given them a common denominator of comparison. It lists over 2000 standards from the thirty-three countries which have published their own national standards for screw threads, and illustrates more than a hundred screw thread forms. This guide, which will be of no little value to those concerned with the supply or manufacture of threaded parts for other countries, is available at a nominal charge of 10s. upon application to W. H. A. Robertson and Co., Ltd.

NICKEL-CHROMIUM CASTING ALLOY.—It is announced by Henry Wiggin and Co., Ltd., that "Nimocast 713C" nickel-chromium casting alloy has been added to its range of "Nimocast" alloys. This alloy is the firm's equivalent of "Inconel 713C," an investment casting alloy for high-temperature service developed in the research laboratories of the International Nickel Company, Inc., and already specified for the turbine rotor blading of a number of American gas-turbine aero-engines. "Nimocast 713C," one of a number of complex high-nickel casting alloys developed in recent years for high-temperature turbine blading, combines outstanding strength with excellent resistance to thermal fatigue at temperatures up to 980 deg. Cent. It is, therefore, of interest as a possible alternative to wrought alloys, which offer difficult production problems when developed for service at such elevated temperatures. The alloy is readily castable and develops its best properties when cast in vacuum. Alternatively, it can be cast under a protective atmosphere such as argon. A heat-treatment of two hours at 1170 deg. Cent. followed by air cooling is beneficial but not essential unless the maximum mechanical properties are required.

Launches and Trial Trips

REGENT EAGLE, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for the Regent Petroleum Tankships Company, Ltd.; length between perpendiculars 535ft, breadth 71ft 8in, depth 39ft 6in, draught 30ft 6in, deadweight 18,764 tons; twenty-seven cargo oil tanks, one cargo pump room, three 650 tons per hour, single-stage, centrifugal cargo oil pumps, three 150 tons per hour vertical duplex stripping pumps, one 150 tons per hour special products pump; two 100kW steam-driven generators, one 100kW diesel-driven generator; Rowan-Doxford oil engine, six cylinders, 700mm diameter by 2320mm combined stroke, arranged to burn heavy fuel, 7500 b.h.p. Trial, June 18.

BAMBURGH CASTLE, ore carrier; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Bamburgh Shipping Company, Ltd.; length between perpendiculars 485ft, breadth moulded 70ft, depth moulded 40ft 9in, deadweight 16,750 tons on 29ft 6in mean draught; ice strengthening, two long holds, MacGregor steel hatch covers, wing spaces for water ballast, external cathodic protection; two 600 tons per hour ballast pumps, three 200kW diesel-driven generators; Swan, Hunter-Doxford opposed-piston oil engine, four cylinders, 4200 b.h.p. at 110 r.p.m. Trial, June 25.

FRANCE II, weather ship; built by the Forges et Chantiers de la Mediterranée, Le Havre, for the French Government; length between perpendiculars 219ft 10in, breadth moulded 40ft 4in, depth 16ft 5in, draught loaded 15ft 7in, speed 14·8 knots; three Ruston-Paxman 8YLCZ diesel engines, each of 865 h.p., three 605kW generators, two 1050 h.p. electric motors. Trial, June.

TEWKESBURY, cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Alexander Shipping Company, Ltd.; length between perpendiculars 430ft, breadth moulded 61ft 9in, depth moulded to upper deck 38ft 3in, draught loaded 28ft 10in; deadweight 11,900 tons; five holds, one 50-ton, six 12½-ton and eight 5-ton derricks, three 200kW diesel-driven generators; Hawthorn-Doxford opposed-piston oil engine burning heavy oil, 5500 b.h.p. at 115 r.p.m. Trial, June.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

Tues. to Fri., Sept. 15 *to* 18.—Music Hall, Union Street, Aberdeen, Annual Conference.

BRITISH INSTITUTE OF MANAGEMENT

Mon., Sept. 21.—Recital Room, Royal Festival Hall, London, One-day Conference on "Knowing Your Customer," 9.30 a.m.

INSTITUTE OF PHYSICS

Wed. to Fri., Sept. 16 *to* 18.—STRESS ANALYSIS GROUP: The University, Birmingham, Annual Residential Conference.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Sept. 22.—Grand Council Chamber, The Federation of British Industries, 21, Tothill Street, Westminster, London, S.W.1, General Meeting; Presidential Address, R. A. Smeddle, 5.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 1.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Raising of H.M. Submarine 'Truculent,'" L. Hackman, 7 p.m.

Tues., Sept. 8.—EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, Members' Evening, 7 p.m. ★ MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester Chairman's "At Home," 7.15 p.m.

Wed., Sept. 9.—DUNDEE BRANCH: Taypark Hotel, West Ferry, Dundee, "Air Cooled Diesel Engine Development," P. L. Johnson, 7.30 p.m. ★ WESTERN BRANCH: Royal Clarence Hotel, Cathedral Close, Exeter, "Glass in Industry," 7.15 p.m.

Thurs., Sept. 10.—NORTH-EAST BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "The Wilston Project," G. C. Lanham, 7 p.m.

Wed., Sept. 16.—KENT BRANCH: Kings Head Hotel, High Street, Rochester, "Industrial Law and the Engineer," R. Cambridge, 7 p.m.

Thurs., Sept. 17.—BLACKBURN BRANCH: Castle Hotel, Blackburn, Joint Meeting with the Institute of Fuel, "Films and Lectures," E. A. Taylor, 7.30 p.m.

Tues., Sept. 22.—SOUTH WALES BRANCH: South Wales Engineers' Institution, Park Place, Cardiff, Technical Films, 7.30 p.m.

Thurs., Sept. 24.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Basic Electronics in Industry and Commerce," R. H. Garner, 7.15 p.m. ★ MERSEYSIDE AND NORTH WALES: Exchange Hotel, Liverpool, "Mounting and Maintenance of Roller Bearings," E. Taylor, 7.15 p.m. ★ NORTH-EAST BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The History and Development of Rotary Air Compressors," 7 p.m. ★ SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Rolling Plant," P. A. Clark, 7.30 p.m.

Fri., Sept. 25.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Works Engineering," R. T. Wells, 7.30 p.m.

Mon., Sept. 28.—WEST AND EAST YORKSHIRE BRANCH: Houldsworth School of Applied Science, The University, Leeds, "Operational Research," G. D. Jordan, 7.30 p.m.

NATIONAL ASSOCIATION OF DROP FORGERS AND STAMPERS

Wed., Sept. 16.—Botanical Gardens, Birmingham, One-day Symposium on "Spark Machining."

PHYSICAL SOCIETY

Mon. and Tues., Sept. 14 *and* 15.—Department of Natural Philosophy, The University, Edinburgh, Conference on "Nuclear Physics," 9.30 a.m.

Thurs. and Fri., Sept. 17 *and* 18.—Imperial College, The University of London, Conference on "The Physics of Very High Temperatures," 9.30 a.m.

Catalogues and Brochures

JENKS BROTHERS, Ltd., Britool Works, Bushbury, Wolverhampton.—Leaflet describing an adjustable presetting torque wrench.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Folder containing details of new and improved blast-furnace refractories.

BAILEY METERS AND CONTROLS, Ltd., Purley Way, Croydon.—Leaflet No. (E) E67/1, giving technical details of "Bailey" pH equipment.

EXPANDITE, Ltd., Chase Road, London, N.W.10.—A short history, written to mark the twenty-fifth anniversary of the foundation of the parent company.

THE MIDLAND HEATING AND VENTILATION COMPANY, Ltd. Bedford Road, Birmingham, 11.—Illustrated leaflet describing the "Midac" wet dust arresters.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., Norwich.—Illustrated folder describing the "Selector" Series II winch, the "Selector" self-contained winch, and a new "Corrector" a.c. winch.

SMITHS AIRCRAFT INSTRUMENTS, Ltd., Kelvin House, Wembley Park Drive, Wembley, Middlesex.—Leaflet giving details of B.N.C. bayonet connectors and adaptors, small a.c. motors, synchros and generators.

EMIL JAGER K.G. (Agents, Frank Whitelegg, Ltd., 304, High Street, Sutton, Surrey).—Prospectus describing Model GSA mesh welding plant for the production of screening from wires which cross at right angles, in accordance with the electric resistance welding process.

EXPANDED RUBBER COMPANY, Ltd., Mitcham Road, Croydon, Surrey.—Illustrated booklet entitled "Onazote for Cold Storage," containing information about insulation. The booklet is divided into four main sections, sub-zero stores, cold stores, cool stores and conditioning rooms.

BRITISH GEON, Ltd., Devonshire House, Piccadilly, London, W.1.—Technical bulletin No. G.16, a comprehensive guide to rigid PVC materials. The publication is divided into three sections dealing with general properties, processing techniques and methods of fabrication.

MACHINE SHOP EQUIPMENT, Ltd., Spenser Street, London, S.W.1.—Publication No. S11, describing the MSE "3C" centrifugal coolant clarifier. Two models are available, catering for throughputs up to 15 and 35 gallons per minute. Detailed specifications are included in the publication.

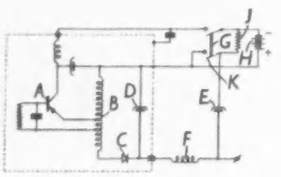
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

ELECTRONICS

812,085. October 2, 1956.—VOLTAGE CONVERSION BY TRANSISTOR OSCILLATORS, Philips Electrical Industries, Ltd., Spencer House, South Place, Finsbury, London, E.C.2.

This invention relates to circuit arrangements for converting low voltages into high voltages by means of a transistor-oscillator which is supplied with power at a low voltage and the output oscillations of which are rectified to provide a high voltage across a smoothing capacitor. It has been found that such circuit arrangements entail difficulties with regard to self-oscillation of the transistor-oscillator, notably if the smoothing capacitor has a comparatively high value or the load supplied with the high voltage has a low impedance. One arrangement according to the invention is shown in the drawing. The circuit



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comprises a transistor *A* which is fed back through an auto-transformer *B* in order to produce pulsatory oscillations which are supplied through a rectifier *C* to a smoothing filter comprising capacitors *D*, *E* and an inductance *F*. The circuit arrangement is so designed that the transistor is conductive during the major part of the time and non-conductive each time only during short intervals, during which pulses are produced with an energy many times exceeding the energy dissipated in the transistor. However, since the transistor has a low initial mutual conductance, self-oscillation involves difficulties which are probably caused by the fact that during the building-up time of the oscillator the capacitors *D*, *E* constitute, via the rectifier, a high load prohibiting building-up. This problem is solved by provision of a switch *G* by means of which the low-voltage supply *H* for the transistor-oscillator is connected into circuit. In the off-position of the switch, capacitor *E* will be charged to a voltage corresponding to that of the supply *H*. When the switch is switched on, the terminal of the capacitor connected to the resistor *J* is connected through the switch arm *K* to the other terminal of the supply. The capacitor thus provides a bias by which the rectifier *C* is blocked, even after sharing its charge with capacitor *D*. Consequently, the oscillation is not initially loaded by these capacitors and builds up until reaching an amplitude corresponding to the bias. It is then able further to build up gradually.—*April* 15, 1959.

WELDED TUBE MANUFACTURE

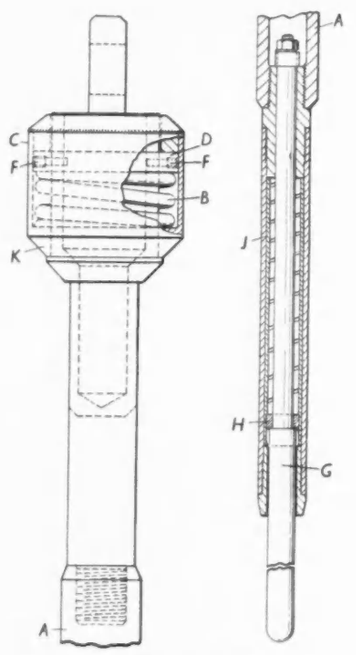
812,915. August 2, 1955.—MANUFACTURE OF SEAM-WELDED TUBING, Tube Products, Ltd., Popes Lane, Oldbury, Worcestershire. (*Inventors: Albert Norton and Harry Osborne Bradshaw.*)

This invention relates to the manufacture of seam-welded tubing from flat strip. In the manufacture of such tubing the flat metal strip is formed by a succession of rolls and the abutting edges continuously welded under pressure. Welding causes a fin or flash inside and outside the tube which is removed by stationary cutting tools past which the tube travels. The inside cutting tool is supported on a bar which is mounted on a rigid bracket entering the open side of the initial U-shaped section of the tube. The bar extends into the bore of the tube beyond the rolls which close the edges together and beyond the welding station. In conventional practice it is a matter of considerable difficulty to control the inside cutting tool so that it removes the flash completely but does not damage the bore of the tube. If the cutting tool strikes an obstacle which it cannot remove, delay often occurs before the tool can be disengaged. According to the invention the bar locates a head comprising a carrier for the cutting tool and a reaction member engaging the side of the tube bore opposite the tool, the tool carrier and the reaction member being urged radially apart by fluid pressure. If some obstruction to the passage of the tube past the cutting tool occurs the fluid pressure can be relaxed to allow the cutting tool to clear the obstacle. Drawings in the specification show the tool in detail.—*May* 6, 1959.

NUCLEAR ENGINEERING

813,584. May 31, 1957.—ARRESTING DEVICES FOR FALLING BODIES, United Kingdom Atomic Energy, Authority, London. (*Inventors: Graham Eades Lindsay and Sydney John Joslin Waldron.*)

In a nuclear reactor having vertically suspended control or shut off rods, the possibility of the failure of the means supporting the control rods with consequent damage when the control rods fall has to be considered. It is an object of this invention to provide means to arrest a falling body in one or more stages depending on the circumstances of the fall so that large impact forces are avoided. Referring to the drawings there is shown a control rod *A*



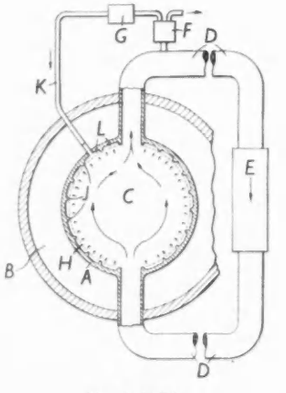
No. 813,584

which has an arresting device comprising two principal parts. At the top of the control rod there is a spring *B* which acts between an arrester cup *C* and a ring *D* secured to the control rod through shear pins *F* and a cylindrical rod support head. At the bottom of the control rod is a broaching arrester mechanism comprising an impact pin *G* carrying a broaching cutter *H* in a stainless steel liner *J* within a tube mounted on the control rod. With this device at the start of a control rod fall the conditions shown in the drawings apply. The rod falls until the face *K* of the cup *C* hits a complementary face around the edge of the hole in the charge pan. The cup is thus arrested and the kinetic energy of the falling rod is absorbed as the spring *B* is compressed between the cup and the ring *D* on the support head. The load which is set up in the spring is taken by the shear pins which couple the ring with the support head. If this load exceeds a predetermined amount the pins fail and the rod and head fall away from the cup and ring *D*. The rod continues to fall freely until the impact pin *G* of the broaching arrester mechanism strikes an impact stool at the foot of the control rod channel. On the impact pin *G* being arrested the broaching cutter *H* is forced along the liner *J*. The liner is cut as the cutter is forced along it and as the energy of the falling rod is dissipated in the broaching operation the rod is finally decelerated to rest. If the rod falls from a position such that the cup receives only a moderate impact on being arrested by the charge pan the shock will be absorbed in the compression spring without fracture of the shear pins and the rod will be arrested with no damage. However, if the impact is more serious, damage is confined to the shear pins and the liner which can easily be replaced. The liner has an internal helical groove to ensure that the cuttings produced are in the form of chippings which will not cause jamming of the broach.—*May* 21, 1959.

NUCLEAR REACTORS

813,723. May 15, 1956.—NUCLEAR REACTORS, United Kingdom Atomic Energy Authority, London. (*Inventor: Robert Spence.*)

This invention relates to nuclear reactors of the kind in which a fluid carrying fissile material is circulated through a core vessel and an external circuit for removing heat generated by fission. According to the present invention the core vessel of a reactor of the kind set forth is provided with a porous or perforated inner lining and means are provided for feeding a substantially non-corrosive fluid to the lining, this fluid being extracted from the working fluid in the external circuit. The arrangement is such that there is an inwardly directed stream of non-corrosive fluid emanating from the lining and continuously tending to keep fissioning product atoms away from the inner surface of the core vessel. In one form of the invention, the porous or perforated inner lining is spaced from the inner surface of the core vessel and means are provided for feeding the non-corrosive fluid to the space between the vessel and the lining. In another form of the invention, the core vessel is provided with a porous lining in intimate contact with the inner surface of the vessel and means are provided for feeding the non-corrosive fluid to said porous lining in such a way that there is an inwardly directed stream of non-corrosive fluid emanating from the lining. Such an arrangement may be achieved for example by feeding the non-corrosive fluid to channels in the wall of the core vessel, the channels being suitably spaced so as to give a uniform distribution of the non-corrosive fluid. The invention is particularly appliable to the homogeneous aqueous reactor in which the working fluid is an aqueous solution of a salt of a fissile metal. Deuterium and oxygen produced by decomposition of the heavy water are, after separation from the fission products, recombined, condensed, and returned to the core vessel through a porous or perforated inner lining such that there is an inwardly directed stream of heavy water emanating from the lining. In the drawing the core vessel *A* consists of a zirconium shell about 1cm thick surrounded by a pressurised blanket *B* of breeding material. Within the core vessel is the aqueous solution *C* of fissionable material which is arranged to circulate around a closed circuit comprising a duct *D* and a heat exchanger *E*. At a point in the duct a gas separator *F* is provided to remove the deuterium and oxygen together with gaseous fission products which have been swept out of the core. The separator also provides for separating the fission product gases from the denterium and oxygen. The former are led off from the system through a duct and the latter are passed to recombining and condensing means *G*. The pressure vessel is provided with an inner lining *H* consisting of a thin sheet of sintered titanium supported a short distance from the inner surface of the pressure vessel by webs *J*. The condensate is fed through a pipe *K* to the space *L* between the inner lining and the vessel in such a manner as to ensure substantially even distribution



No. 813,723

of the condensate. For example the pipe may feed into a circular manifold (not shown) from which a multiplicity of radial branches may extend through the wall of the vessel to ensure even distribution. In operation the condensate flows radially inwards through the inner lining over substantially the whole of the inner surface as indicated by the small arrows, thus tending to flush fissioning atoms produced within the core towards the centre of the pressure vessel into the main circulating stream which carries them out of the core into the duct *D*. Since the duct is not usually required to be transparent to neutrons it can be constructed of less corrodible or heavier material than the vessel.—*May* 21, 1959.

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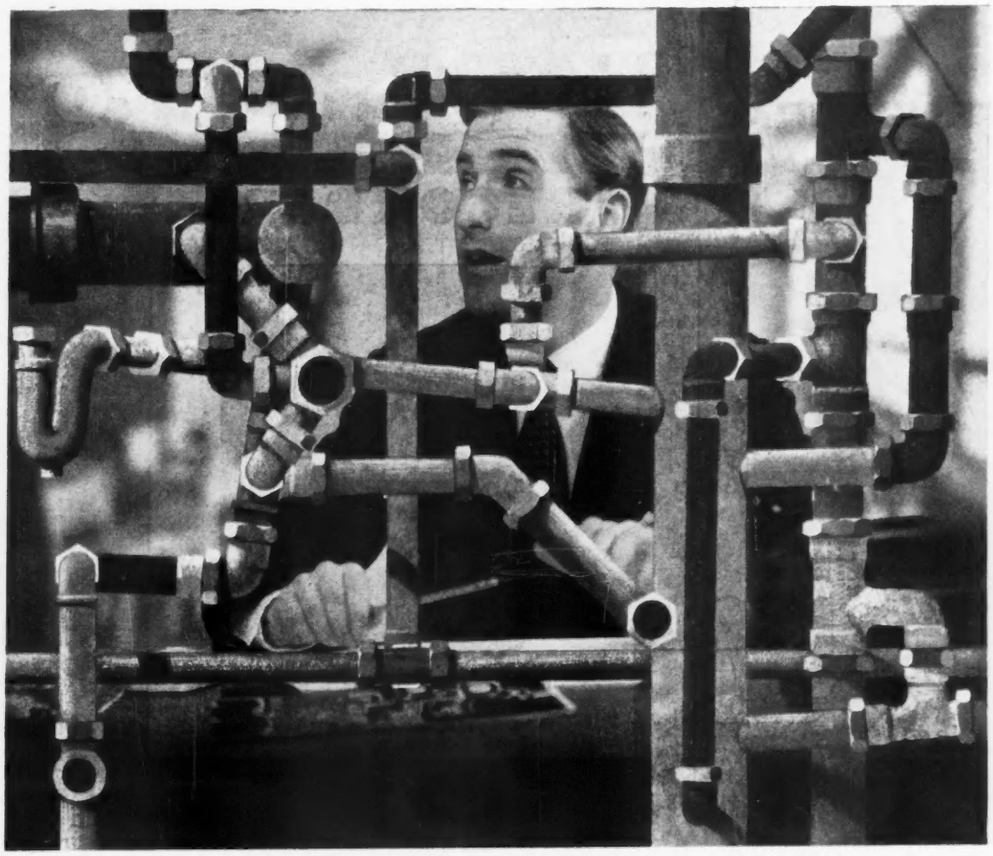

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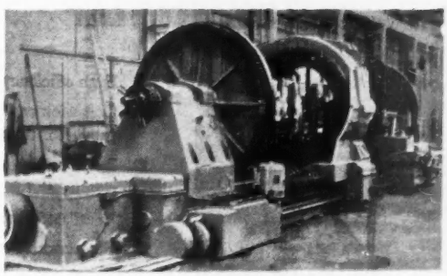

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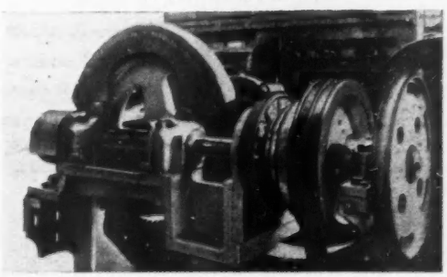

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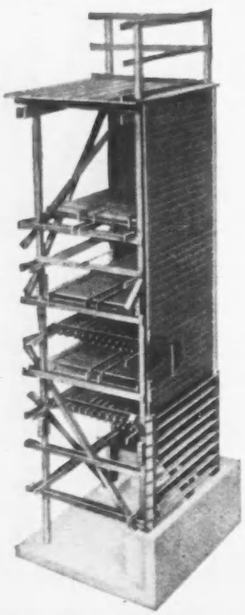

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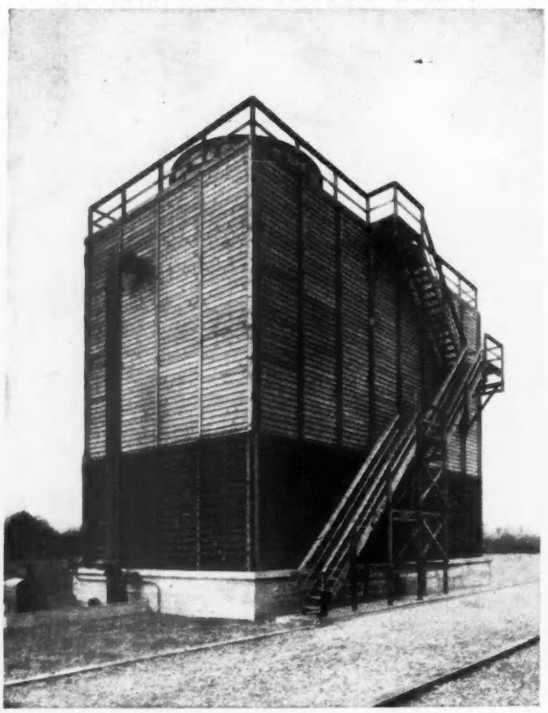

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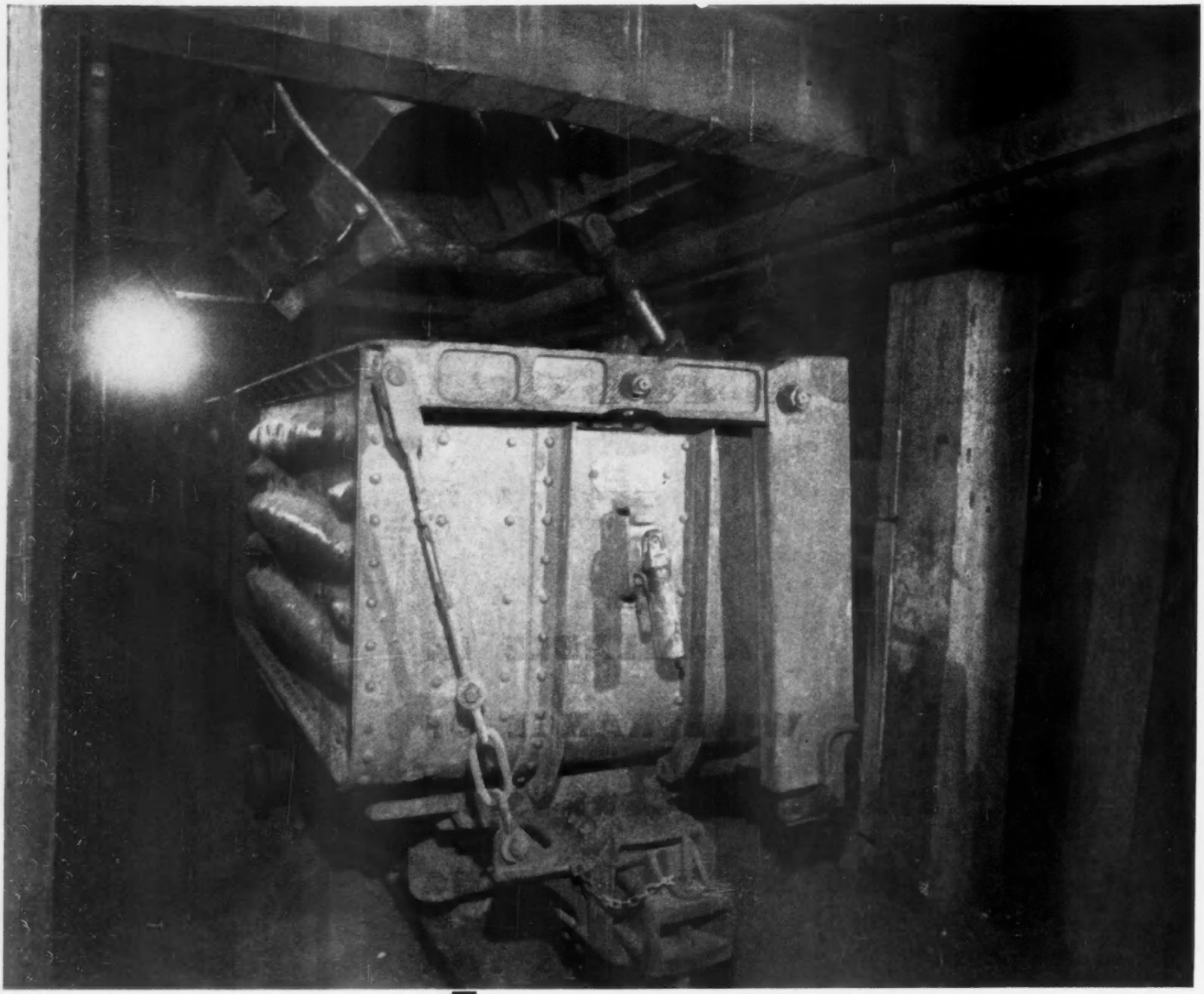

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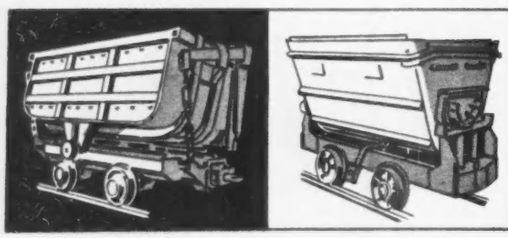

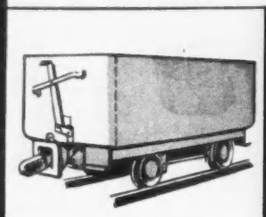

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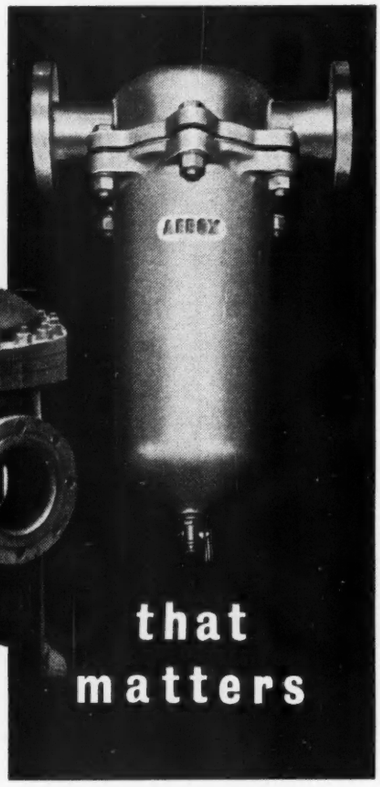

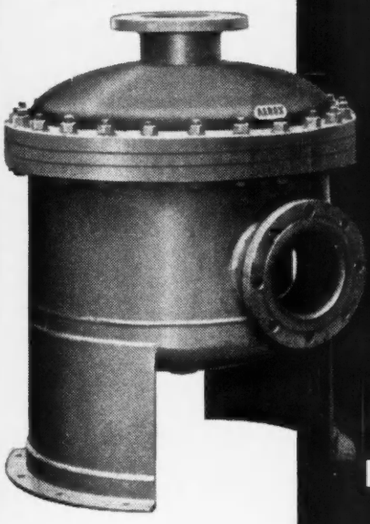

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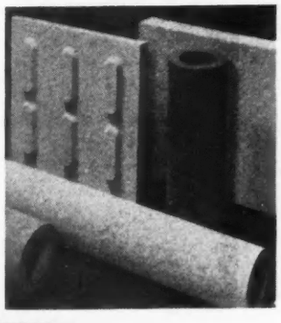

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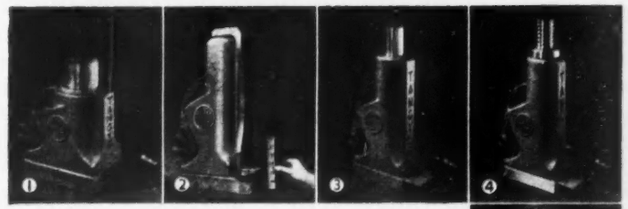

(1) A 6 ins./50 ton with plain ram. (2) Claw attach. on 12 ins./25 ton.
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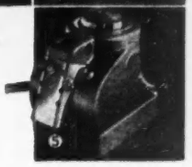

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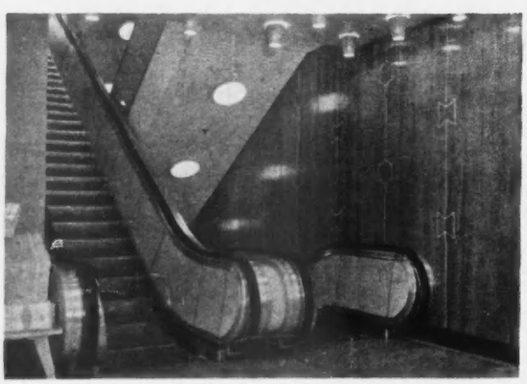

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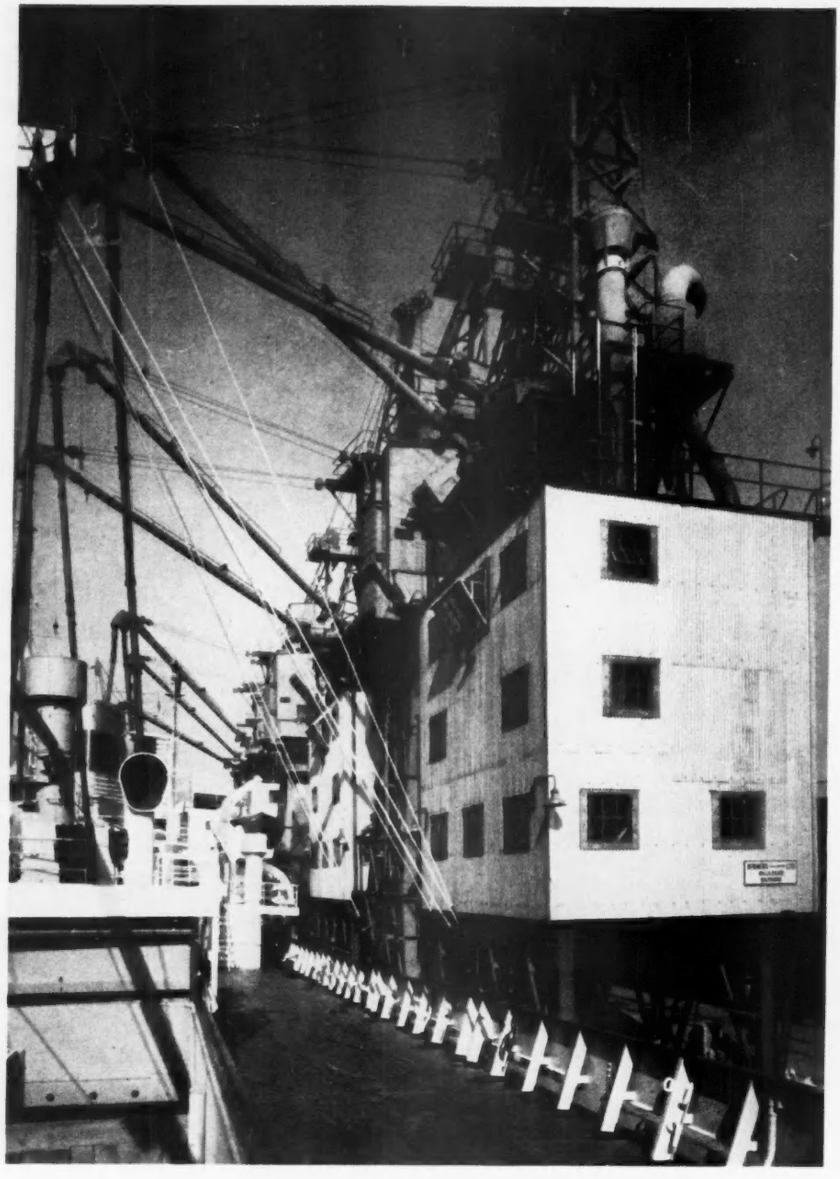

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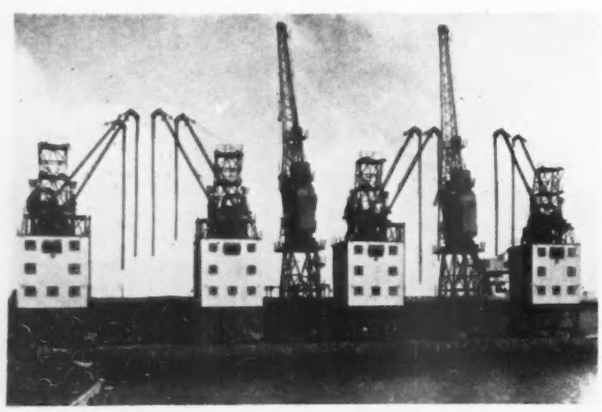

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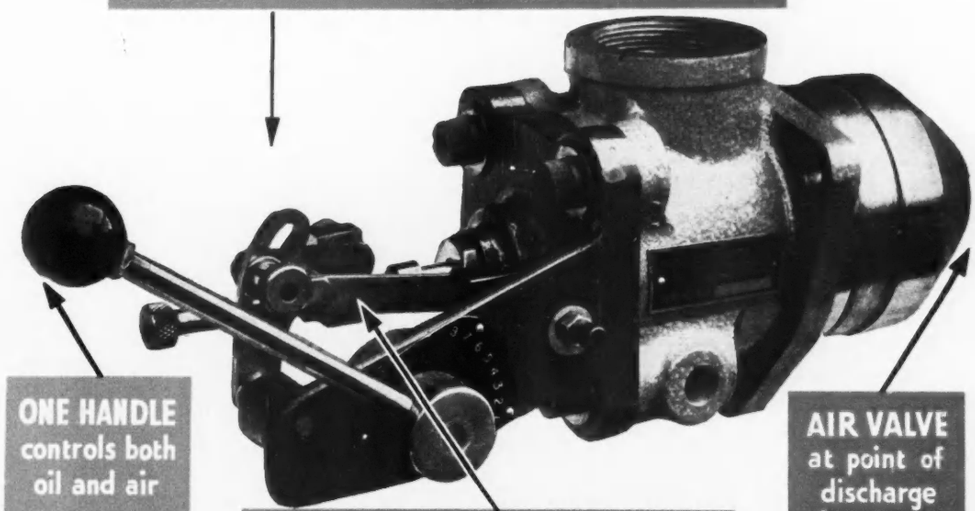

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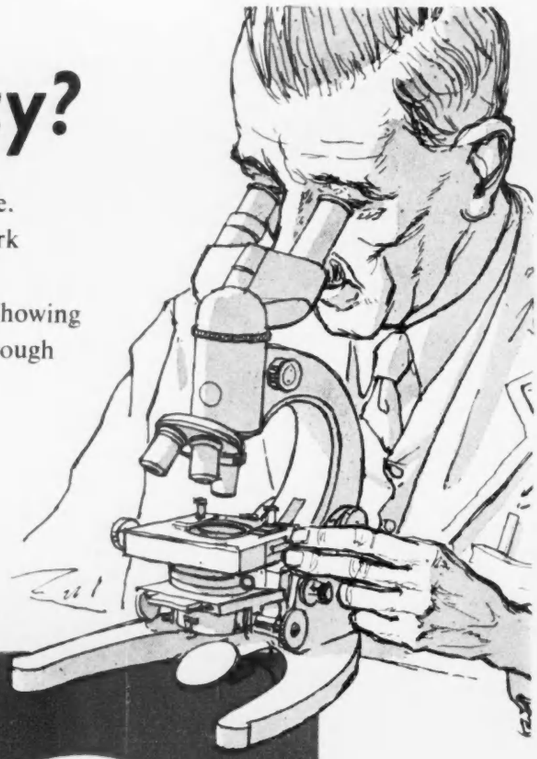
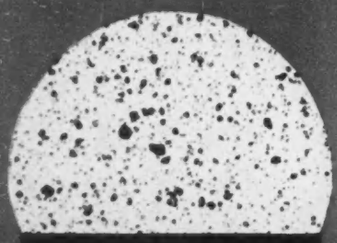
Many filters on the market do not, however. On test, they may start by showing a fair efficiency, but later more and more of the abrasive particles pass through the filter material. Such unstable filters are quite useless, and are no safeguard to your fuel injection equipment whatsoever.

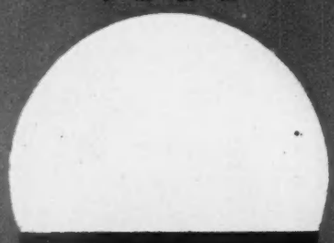
These photomicrographs of fuel tell the story of actual tests.



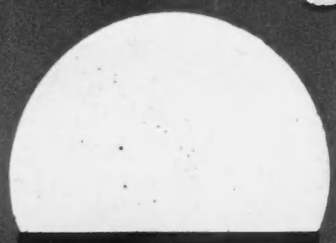
STABLE



1 Fuel laden with abrasive dust, before filtration

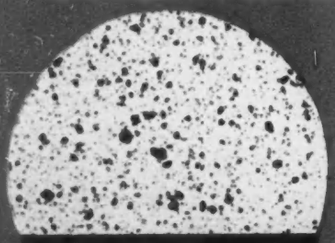


2 The same fuel after passing through a C.A.V. paper element filter at beginning of test

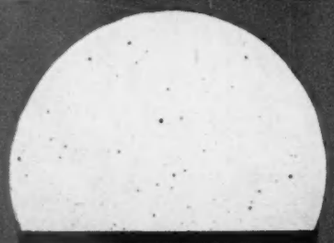


3 Fuel after filtration by the same element when all but choked by waxy sludge and dirt

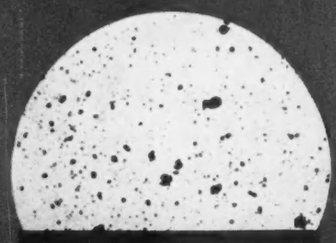
UNSTABLE *and Valueless*



4 The same fuel is used for this test



5 At the beginning of test, filtration is fairly efficient



6 After the filter element is partly choked, the fuel passing through takes with it nearly all the particles of dust

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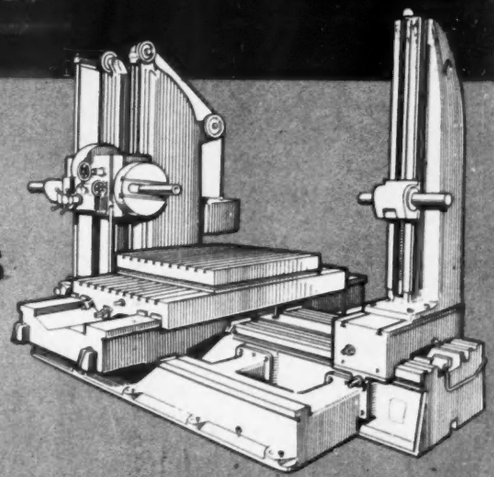

No. 5 Kearns Patent wide bed horizontal borer machining the top face of a Paxman 16 cylinder YL engine (courtesy Davey, Paxman & Co. Ltd.)

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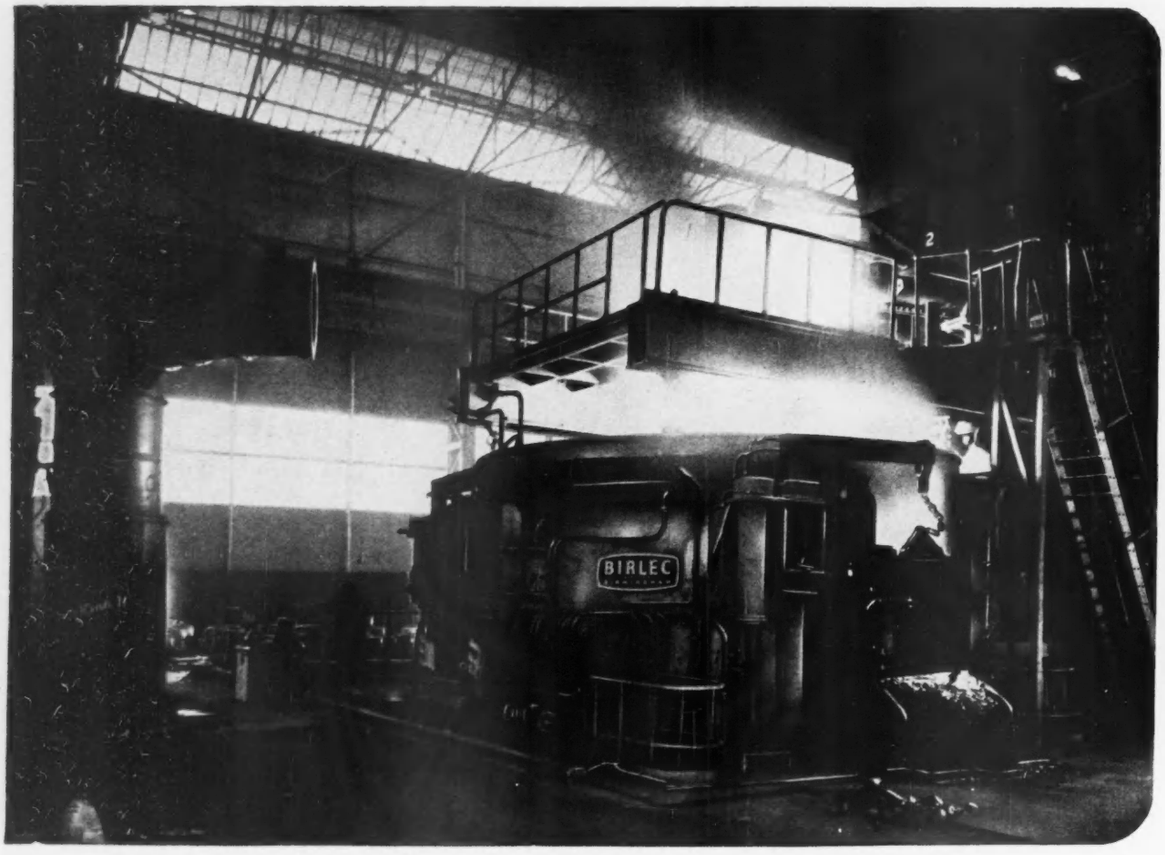

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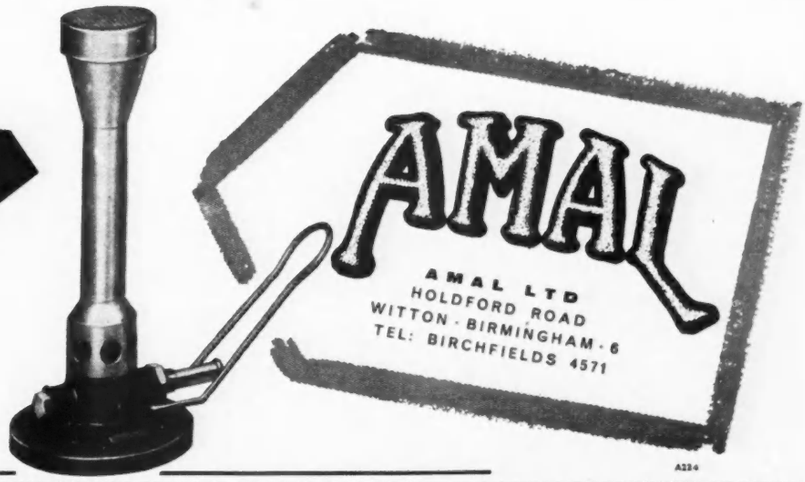

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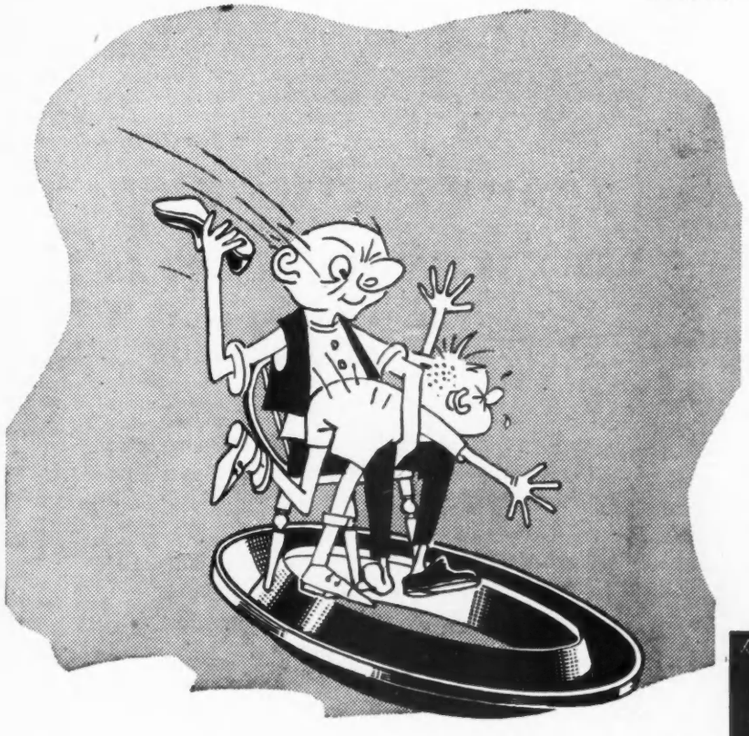

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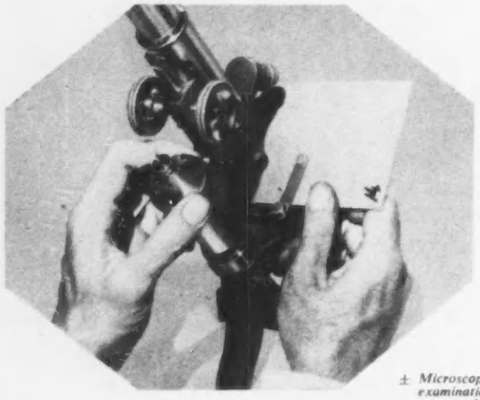

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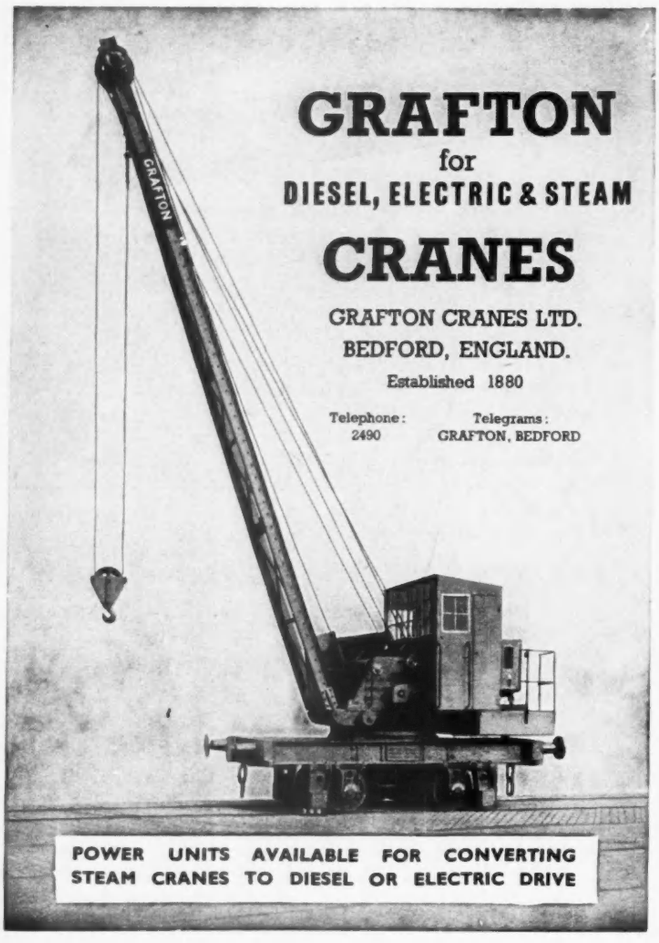

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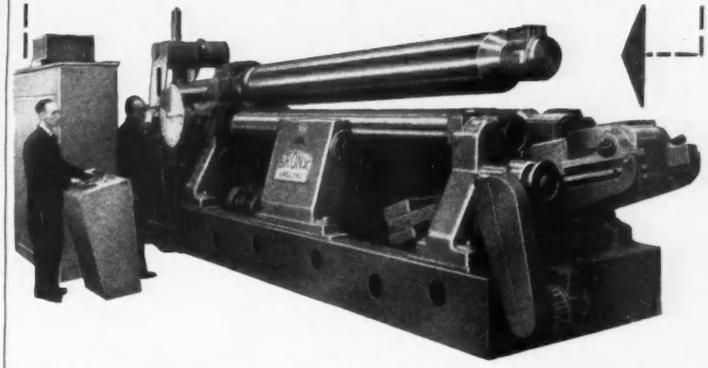

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Illustration shows series PBE 810 with swing-down bearing bracket in down position. Photo by courtesy of Consett Iron & Steel Co. Ltd. Durham

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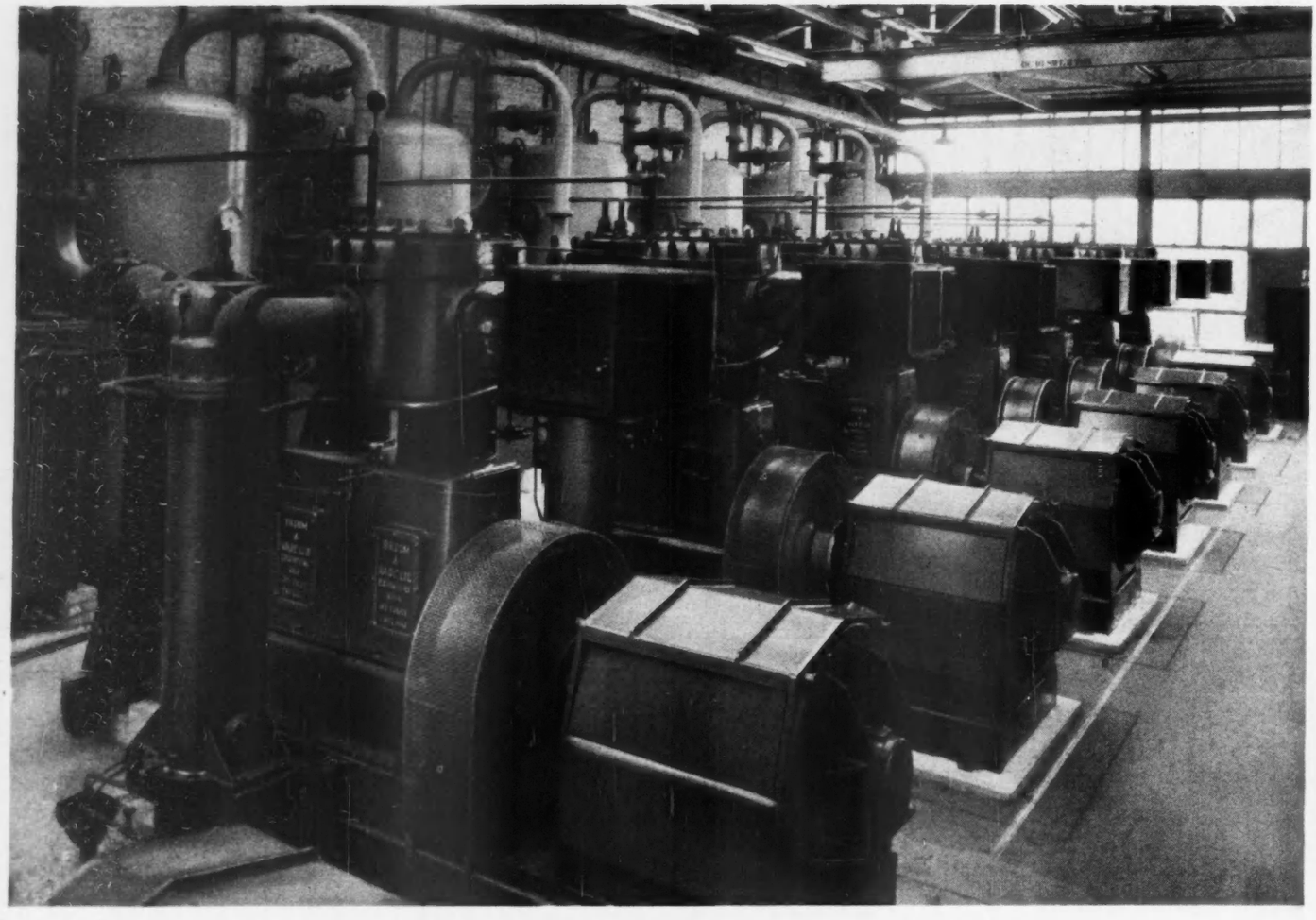

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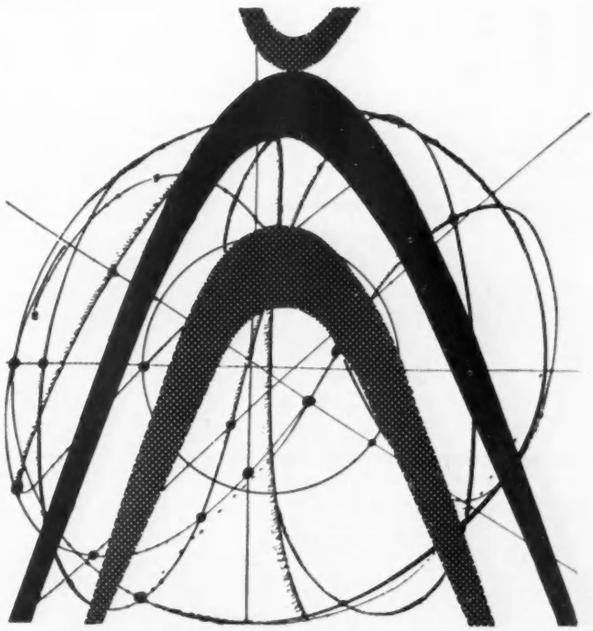

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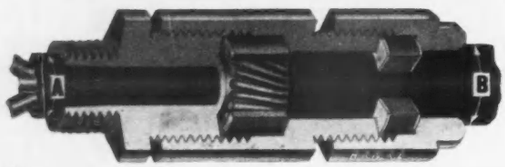
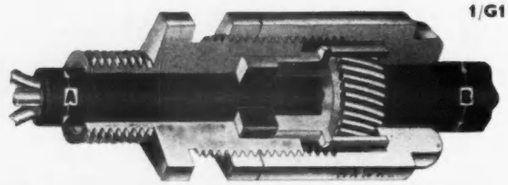


9/G3



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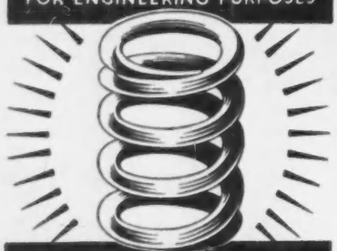

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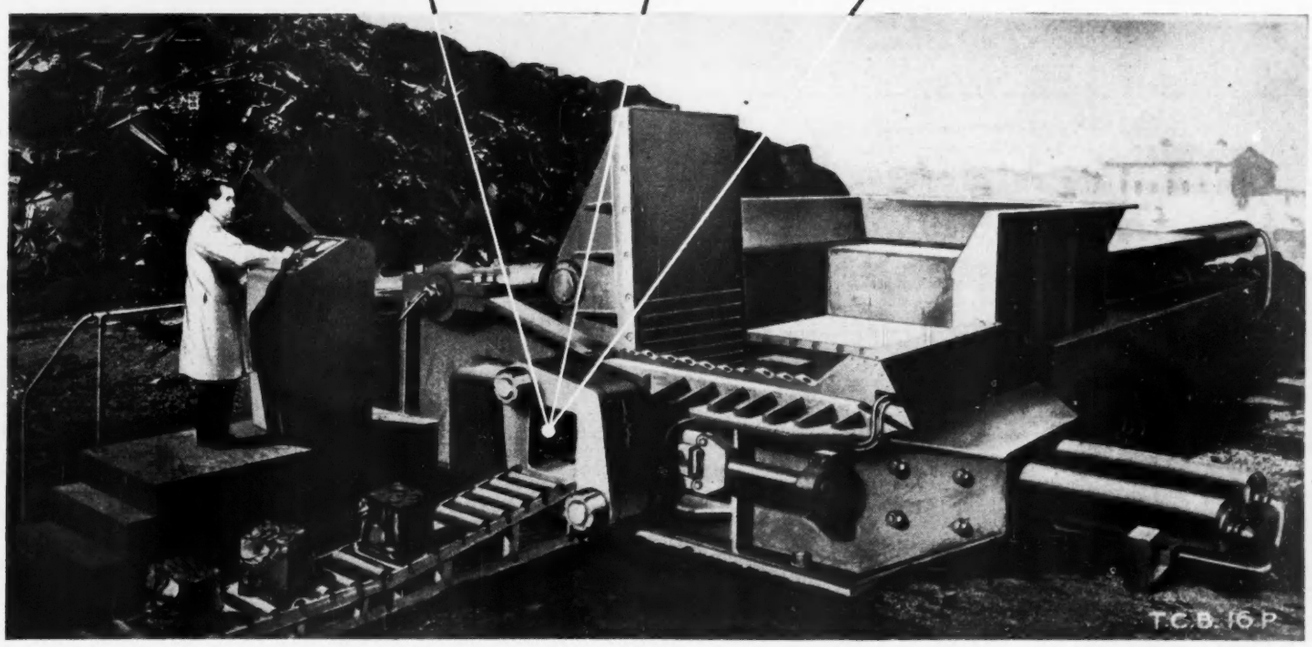

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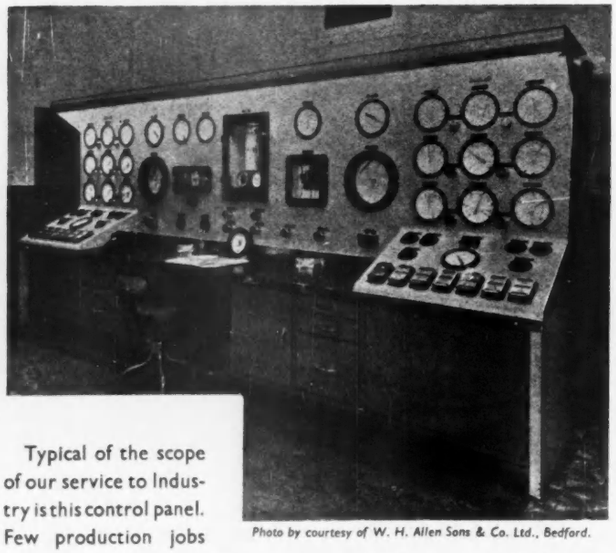

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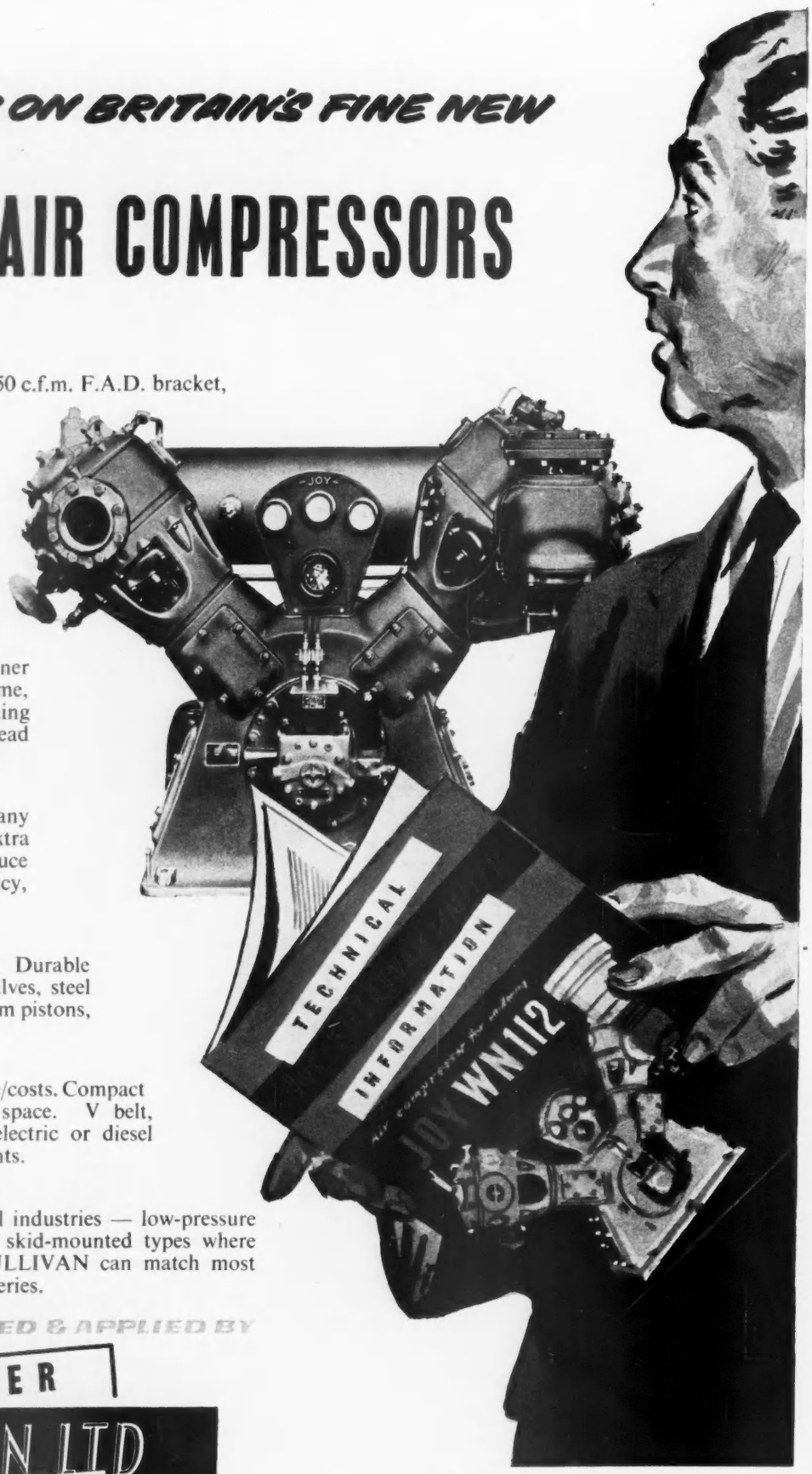

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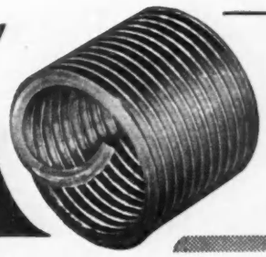

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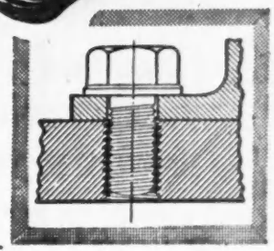

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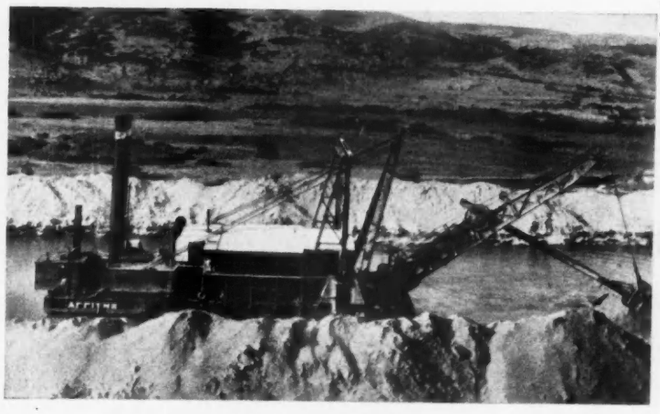

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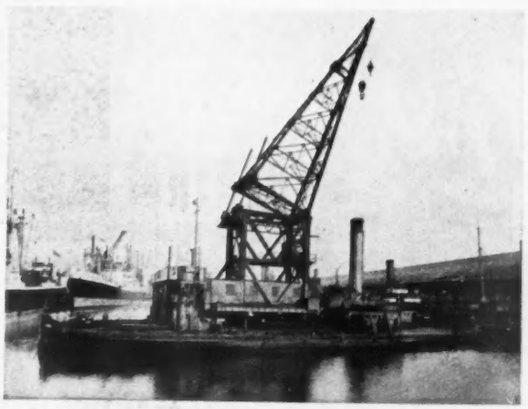

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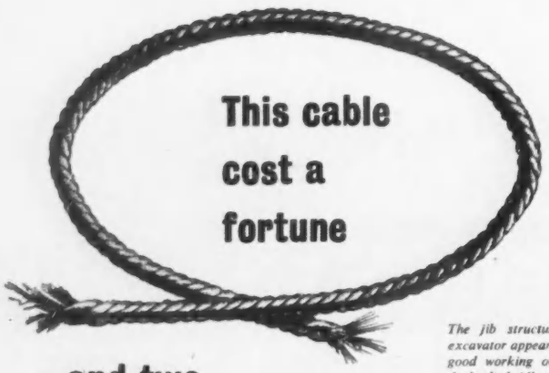

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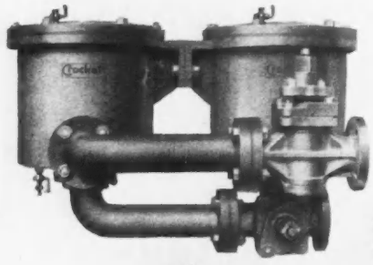

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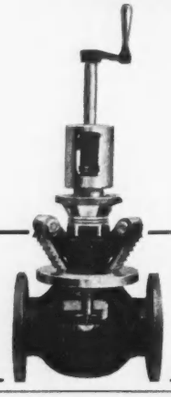

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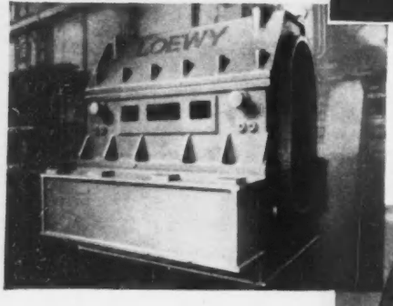

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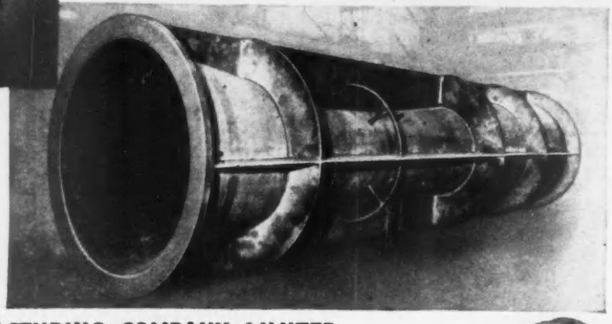

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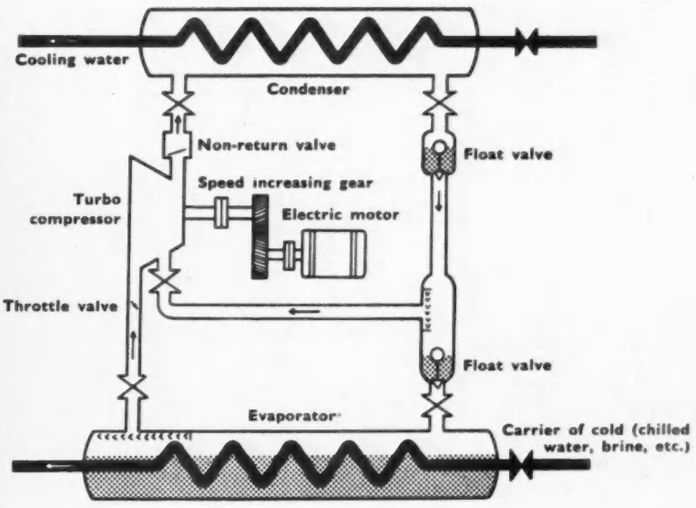

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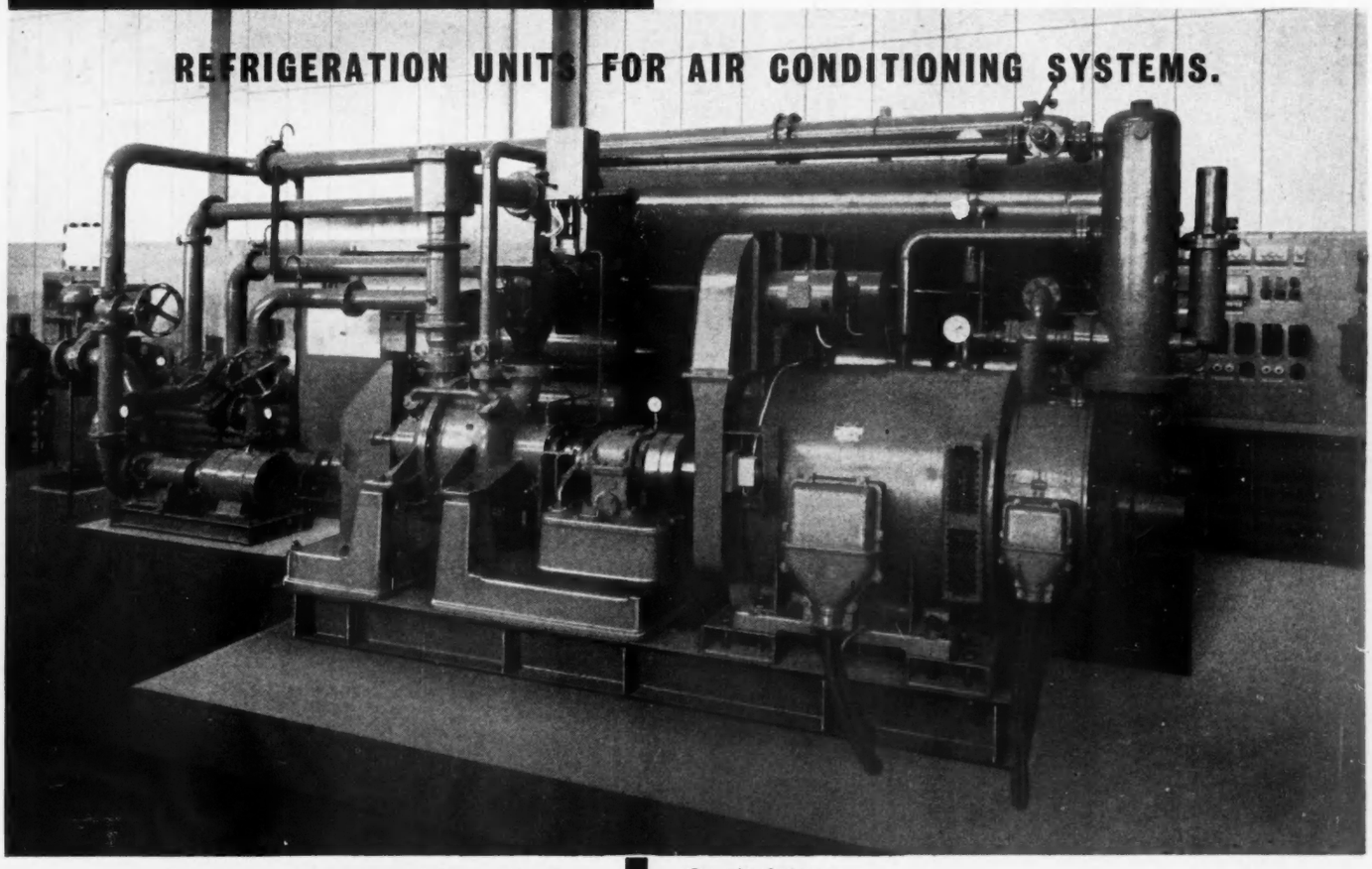

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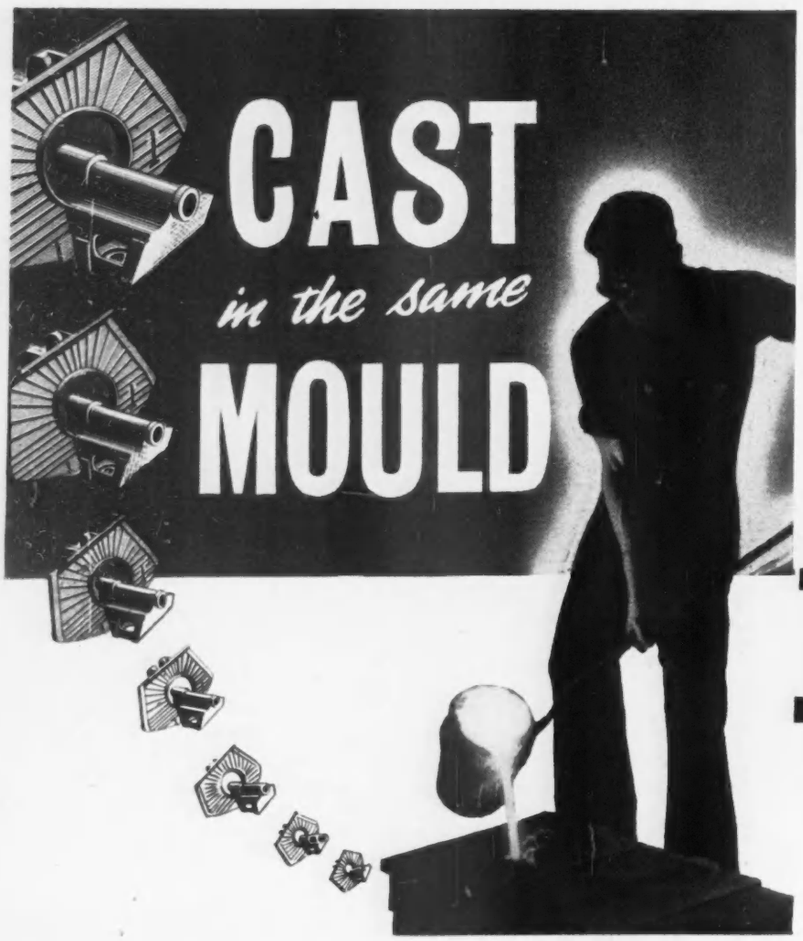

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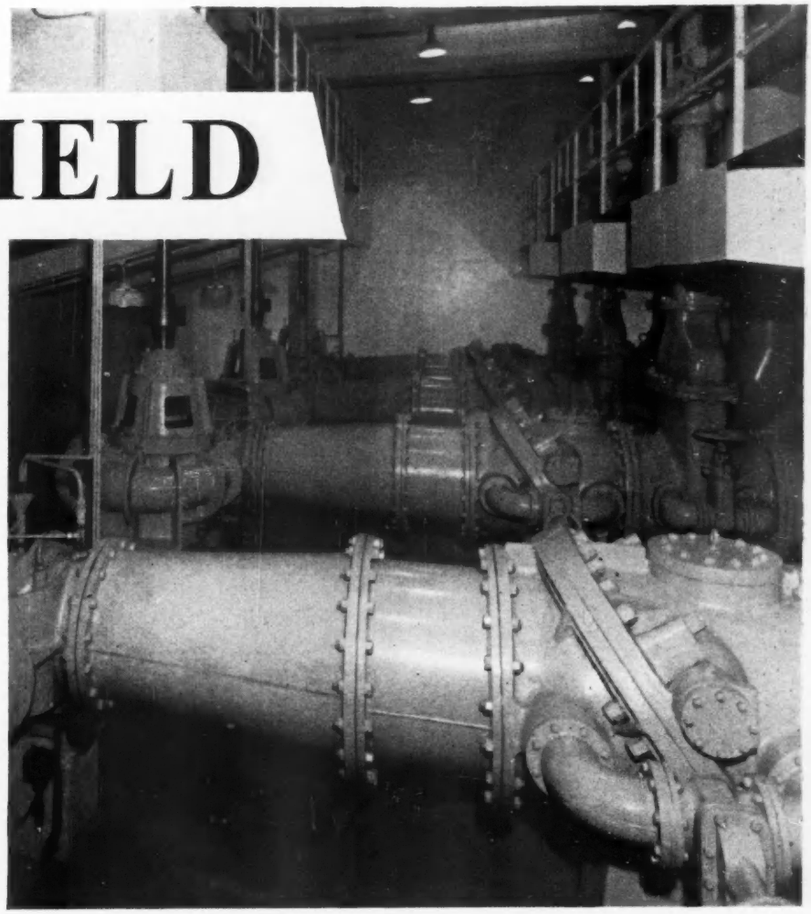

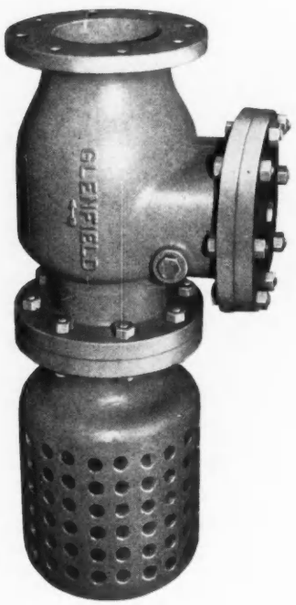

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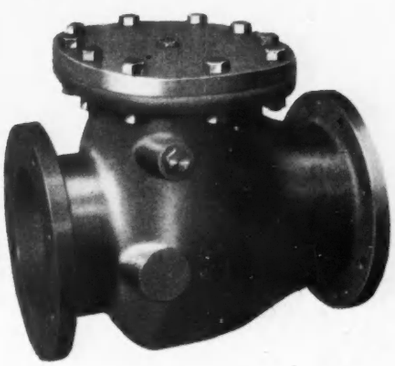

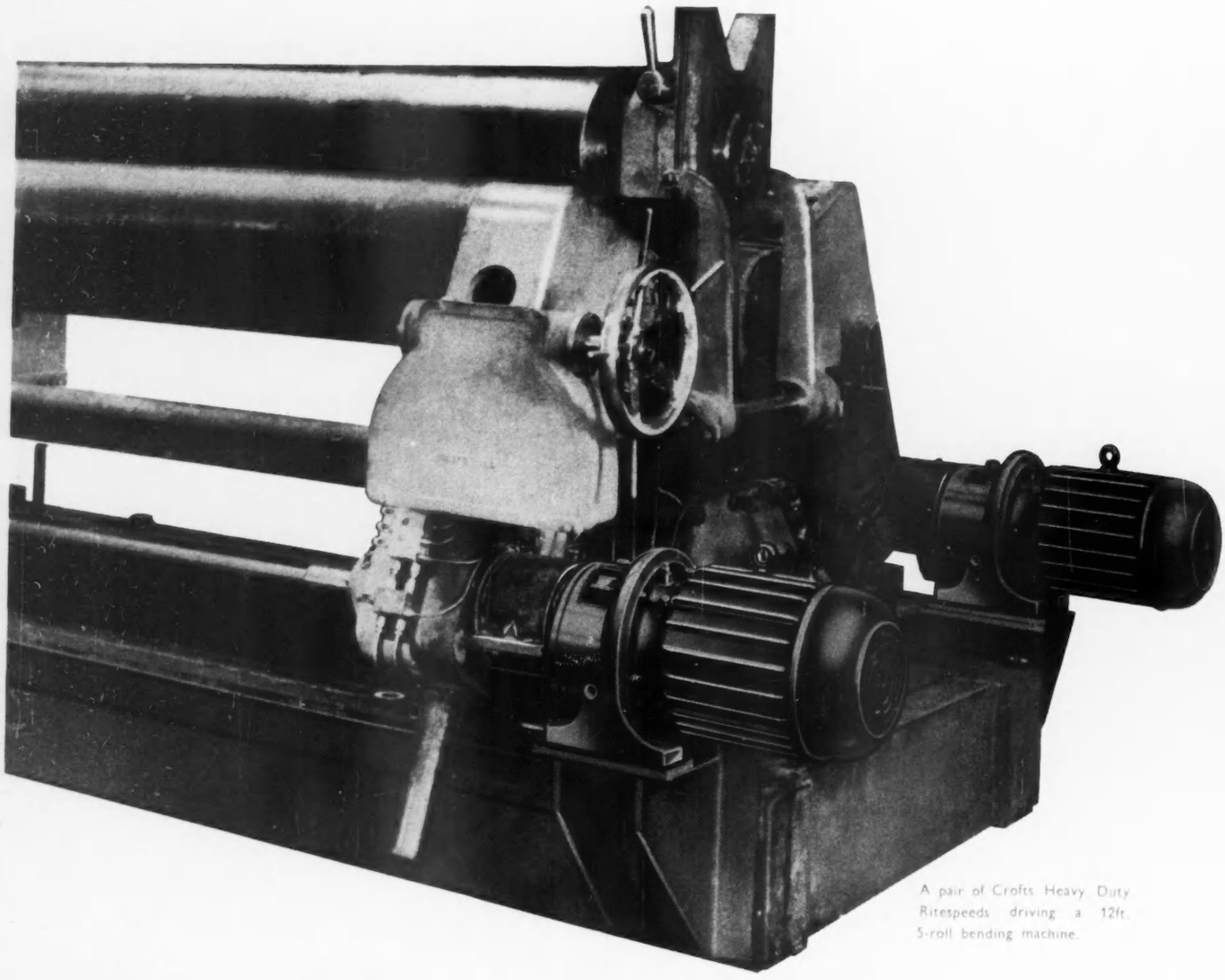

A pair of Crofts Heavy Duty Ritespeeds driving a 12ft. 5-roll bending machine.

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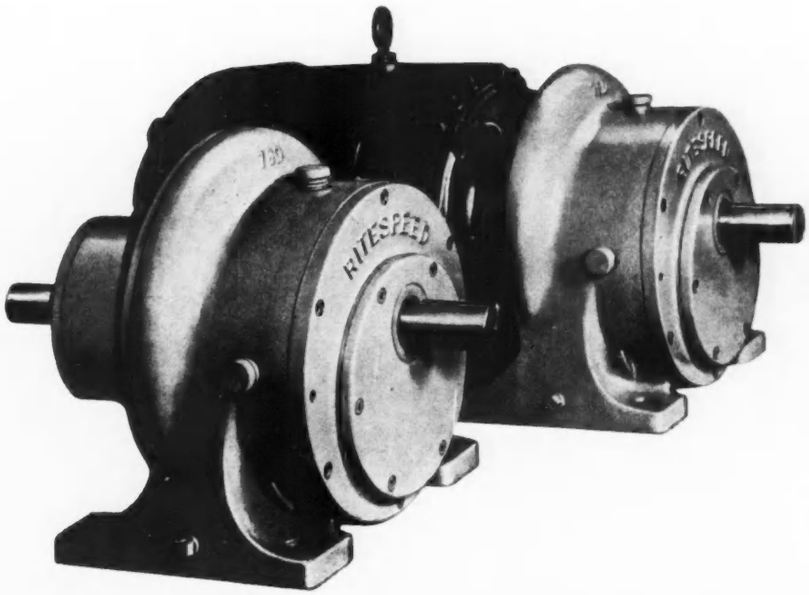

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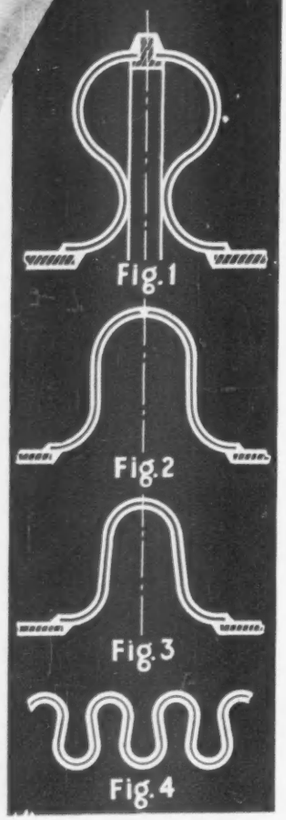

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Fig. 3 A bellows profile which may be formed by deep pressing. This type of expansion fitting is built up in three or more sections with longitudinal welds.

Fig. 4 One of the profiles available for the Aiton "A" type expansion fitting. This unit is made by a special process which obviates the need for circumferential welding at the crown of, and between, convolutions.

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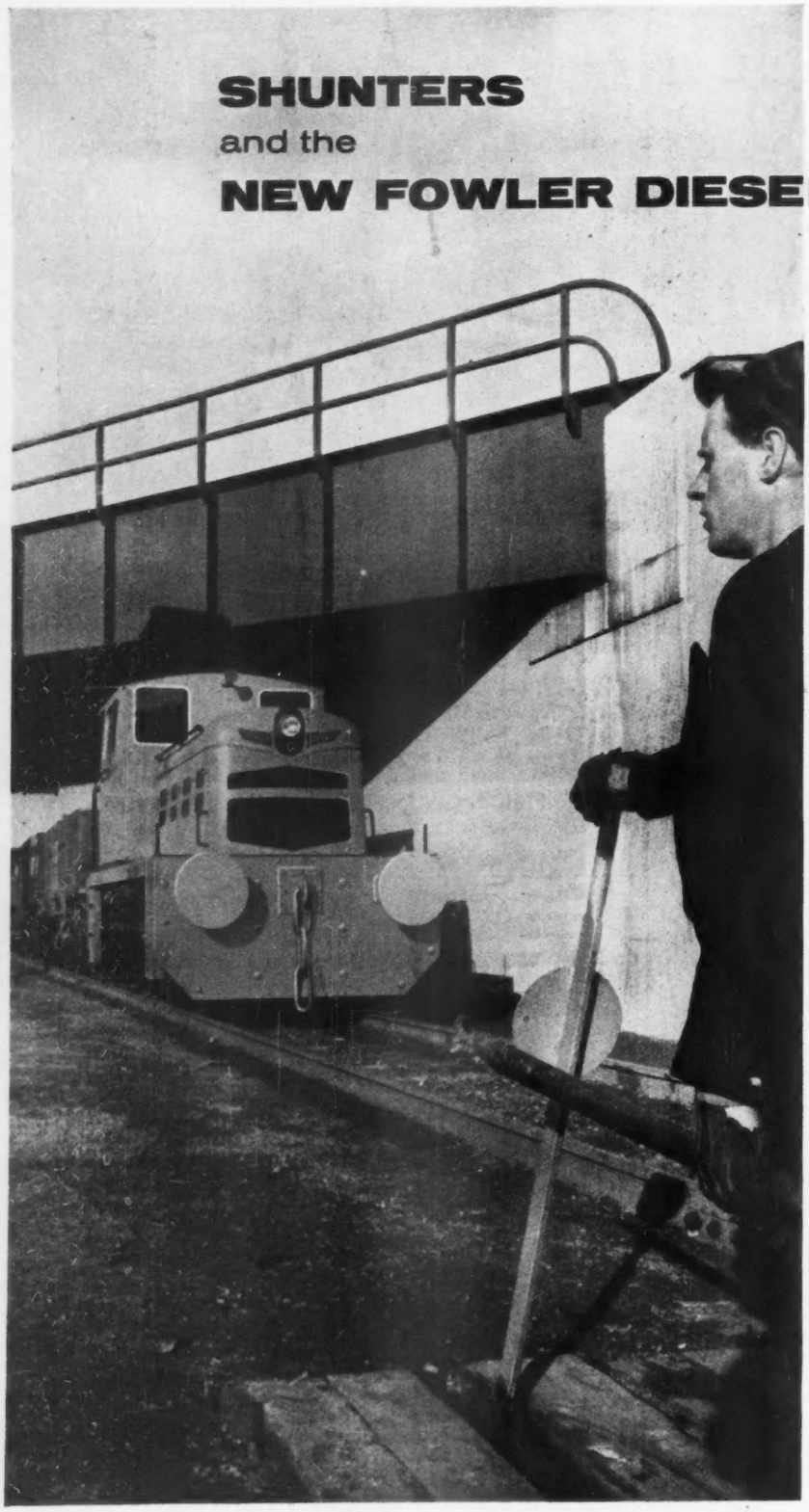

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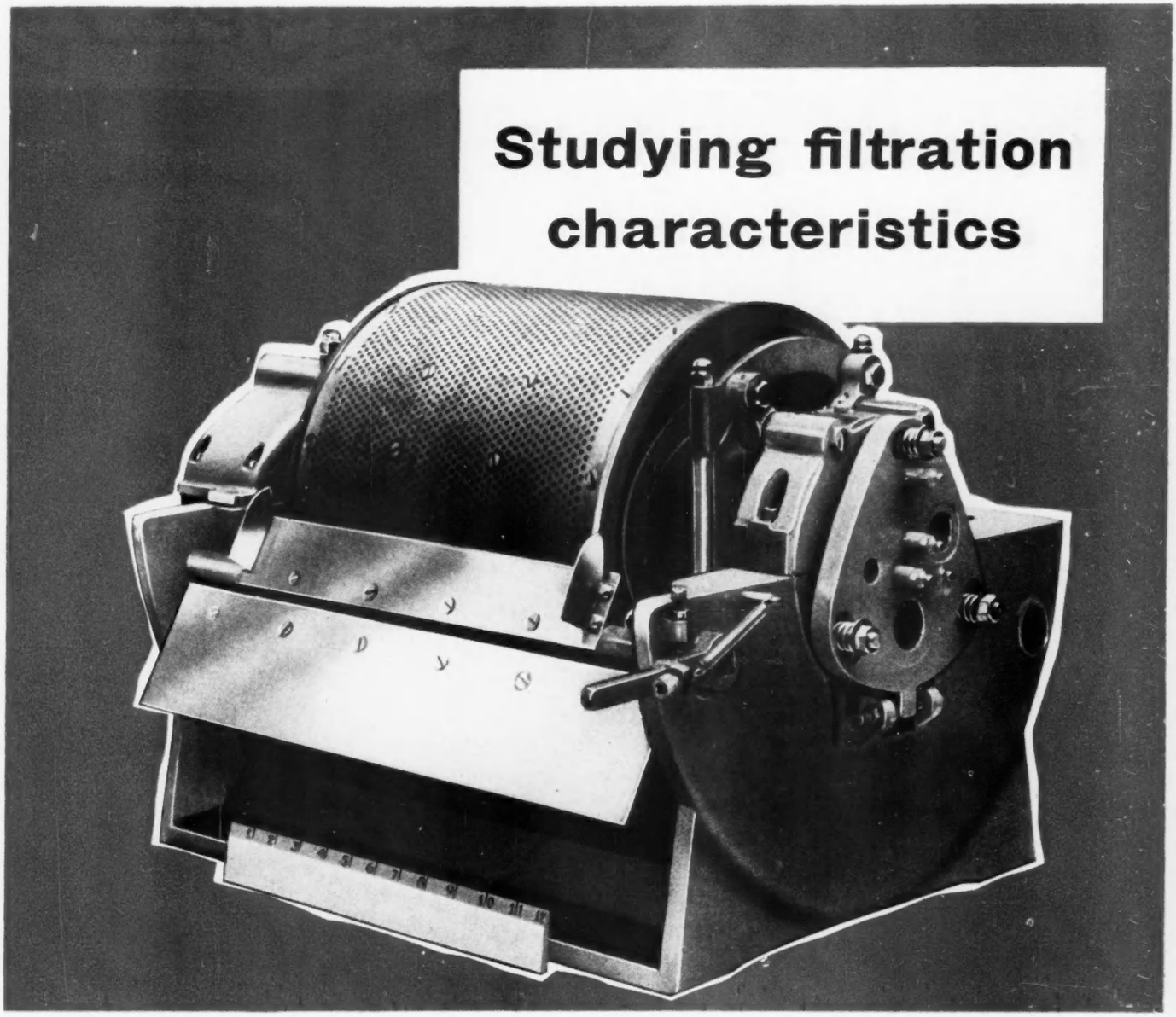

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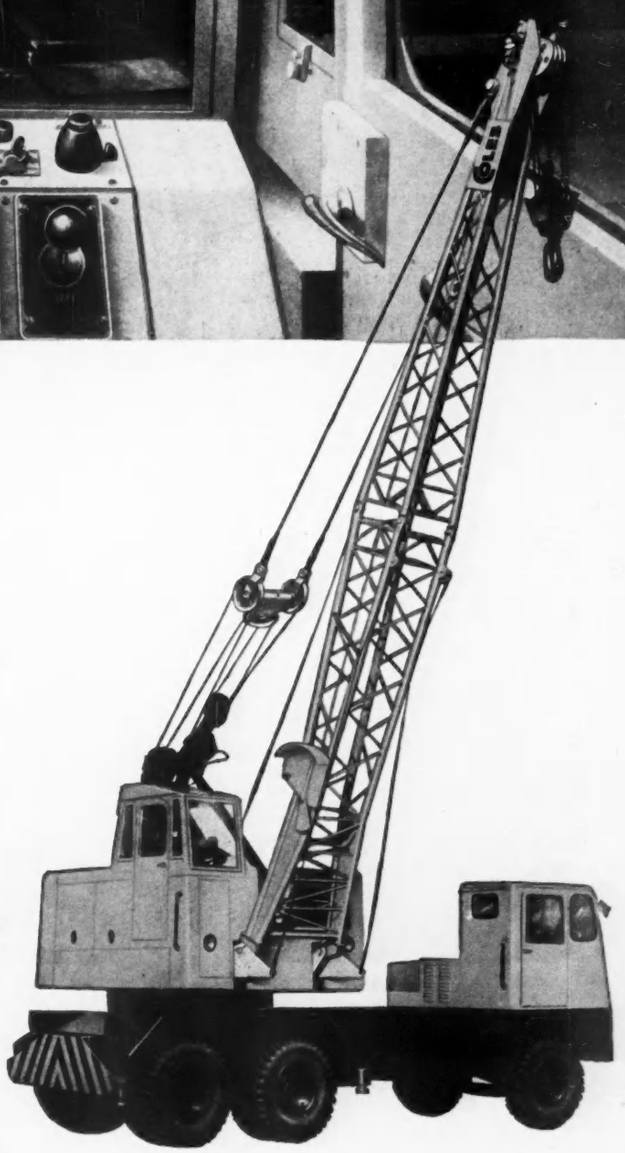


industry COLES CRANES

The jib for the job!

MORRIS

DIESEL-ELECTRIC

MOBILE CRANES

have the reach required!

Whether you want to lift up to 60 feet or up to a mere 15 feet, Morris mobile cranes can be supplied to provide the " reach " required, since the Morris range includes both the length and type of jib for most jobs.

Basically, the essential features of the crane chassis and superstructure remain the same irrespective of the length of the jib or whether it is of the strut type (as illustrated) or the cantilever type.

These features may be summarized as follows :—

Centrally mounted superstructure giving an equal radius clearance and stability when handling loads over the front or back of the crane.

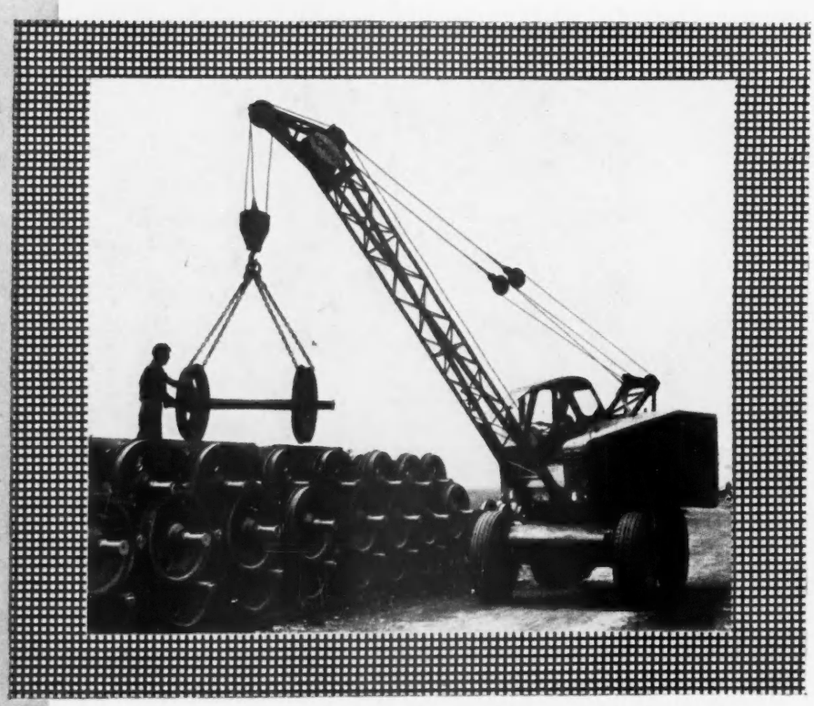
Easy control with no heavy levers to operate—just a finger touch controls all motions.

Flange mounted motors ensuring perfect and permanent alignment. All main assemblies are of unit construction.

Four-speed gearbox allows fast or slow travel according to the load being handled.

Hydro-mechanical brakes on all road wheels.

Fully interchangeable wheels, including tyres, rims, brakes and hubs. These components are interchangeable on all four road wheels of equal size.



By Courtesy of CAMBRIAN WAGGON & ENG. Co. Ltd. CARDIFF

HERBERT MORRIS LTD P.O. Box 7 LOUGHBOROUGH ENGLAND

TELEPHONE : LOUGHBOROUGH 3123

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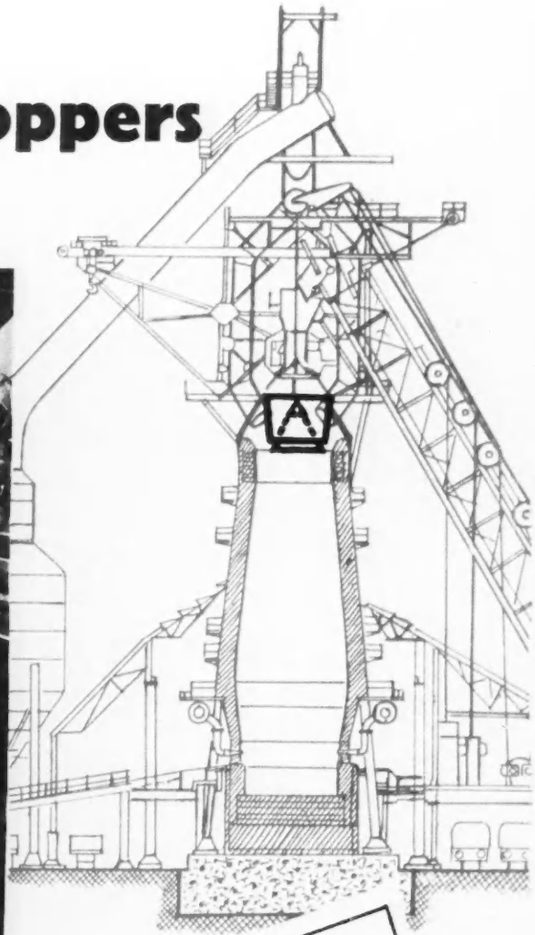
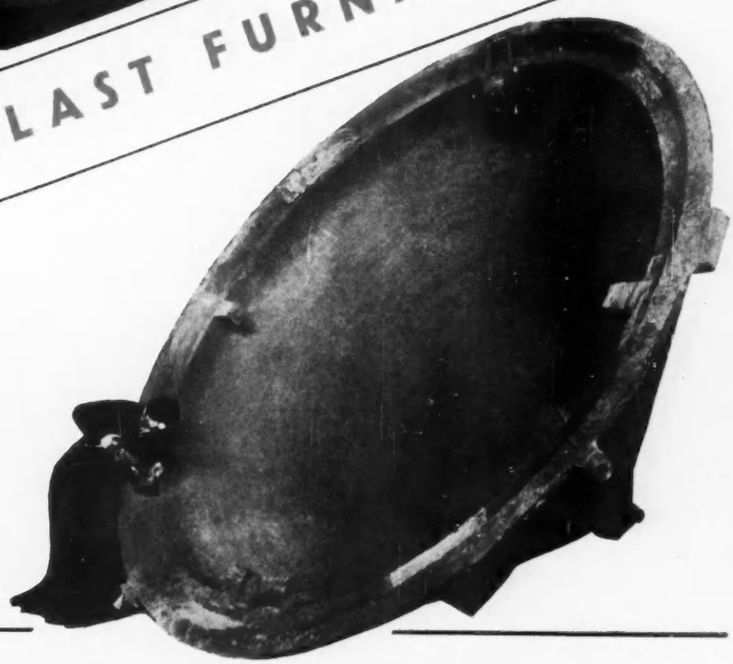


FOR BLAST FURNACES



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WOODWORKING MACHINES ALL OVER THE WORLD

We supply all machinery and complete equipment for sawmills, plywood and veneer plants, furniture factories, carpenters' shops and several other kinds of special woodworking machines. Czechoslovak products are exported all over the world owing to their high standard and first class workmanship.

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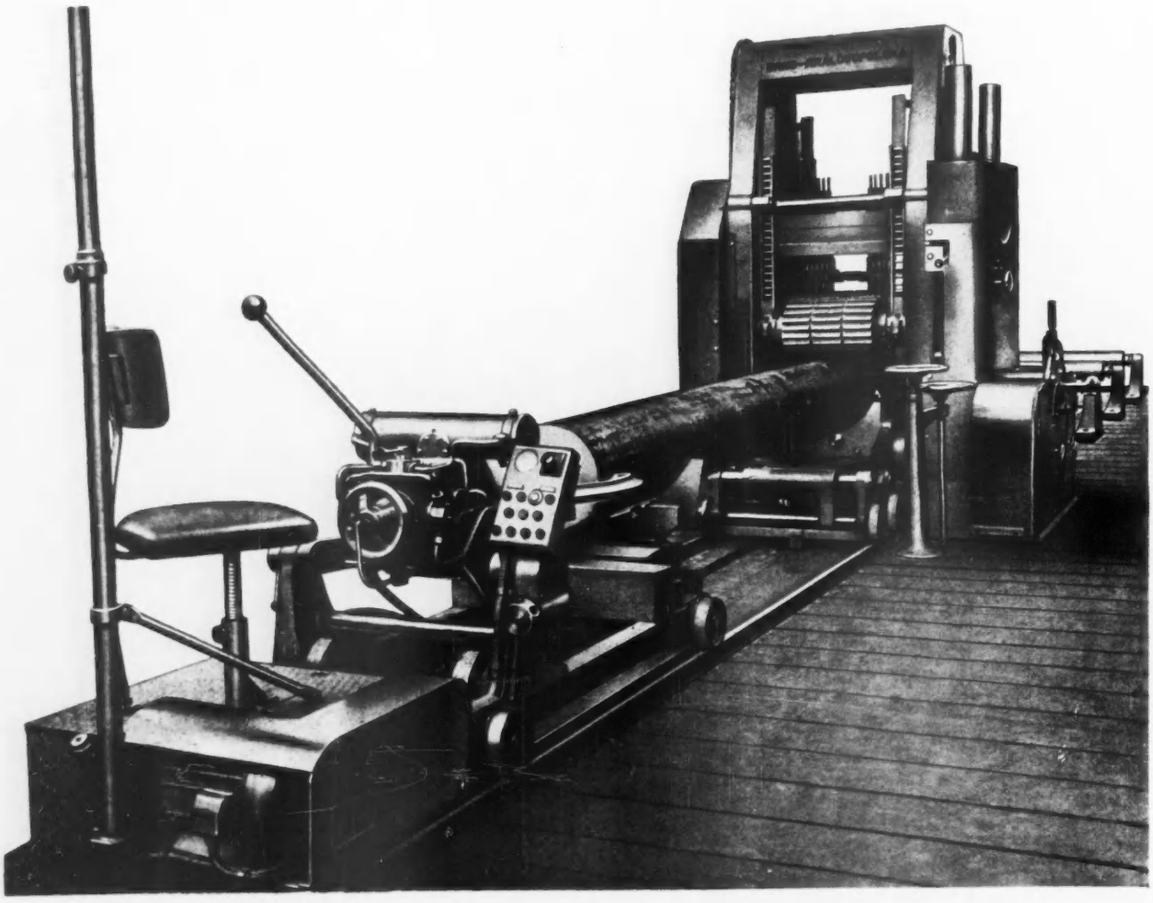

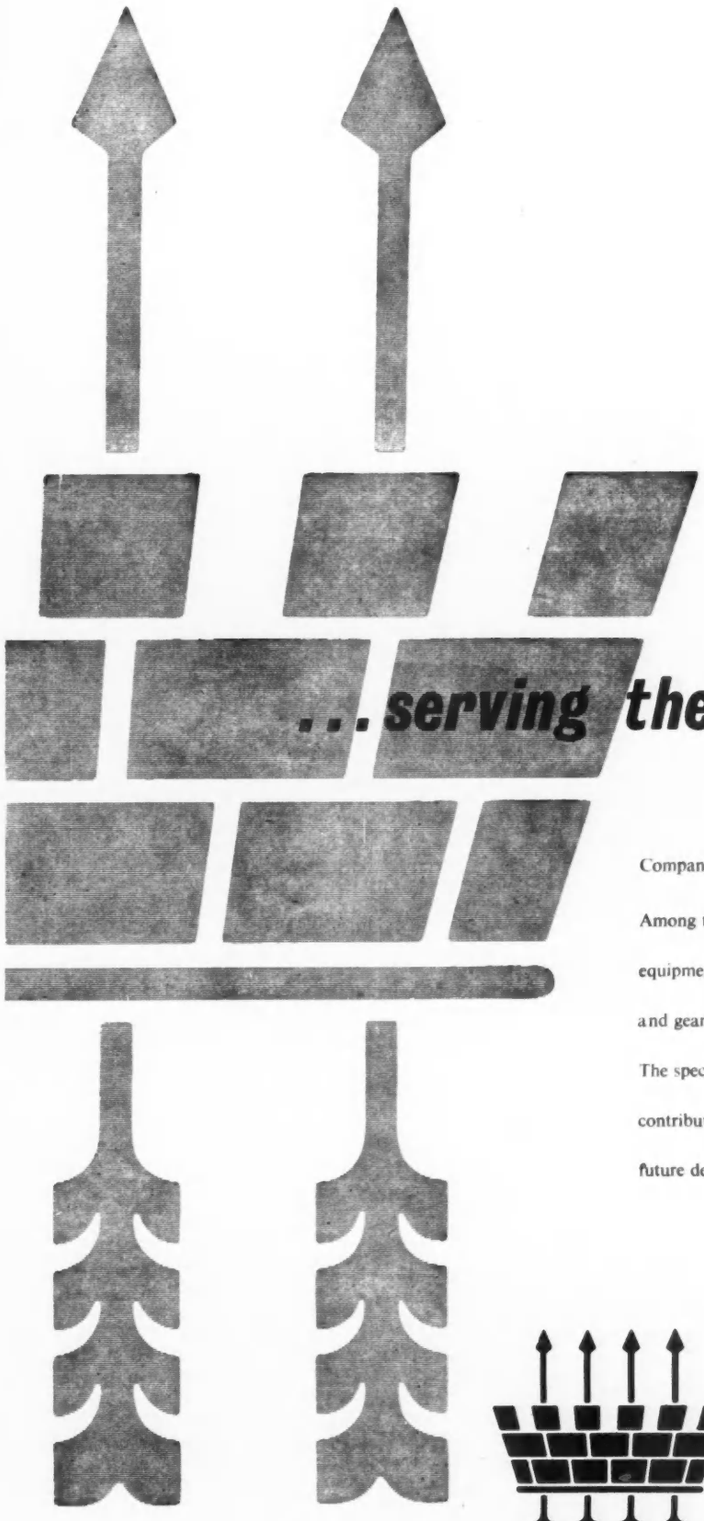

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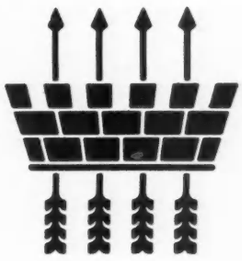
Companies of the Birfield Group serve most branches of industry today.

Among their products of particular interest in Engineering are... filtration equipment, fabric bearings, self-lubricating bearings, transmission equipment and gears, castings of all kinds, forgings and cold extrusions.

The specialized knowledge and wide resources of the Birfield Group have contributed to many important advances in the past and are available for future developments of the Engineering industry.



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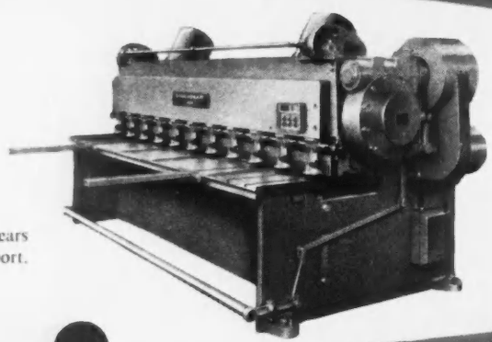
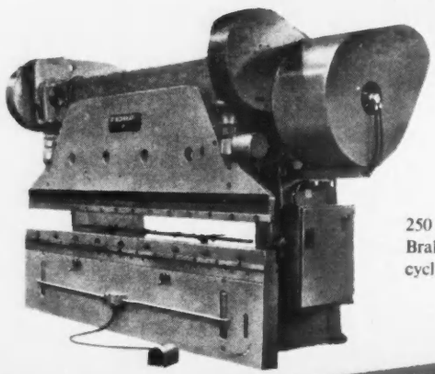
see the **CINCINNATI** exhibit

Stand 1D9

MACHINE TOOL EXHIBITION



½in. × 10ft. Guillotine Shears with magnetic sheet support.



250 ton capacity Press Brake with automatic cycling.

The British Built Cincinnati Press Brake and Guillotine Shears illustrated in this advertisement will be in operation on our Stand 1D9 demonstrating their special features of accuracy, speed and versatility.

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The CINCINNATI SHAPER Co. Ltd.

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The Cincinnati Shaper Company Limited is a wholly owned subsidiary of the Cincinnati Shaper Company, Ohio, U.S.A.

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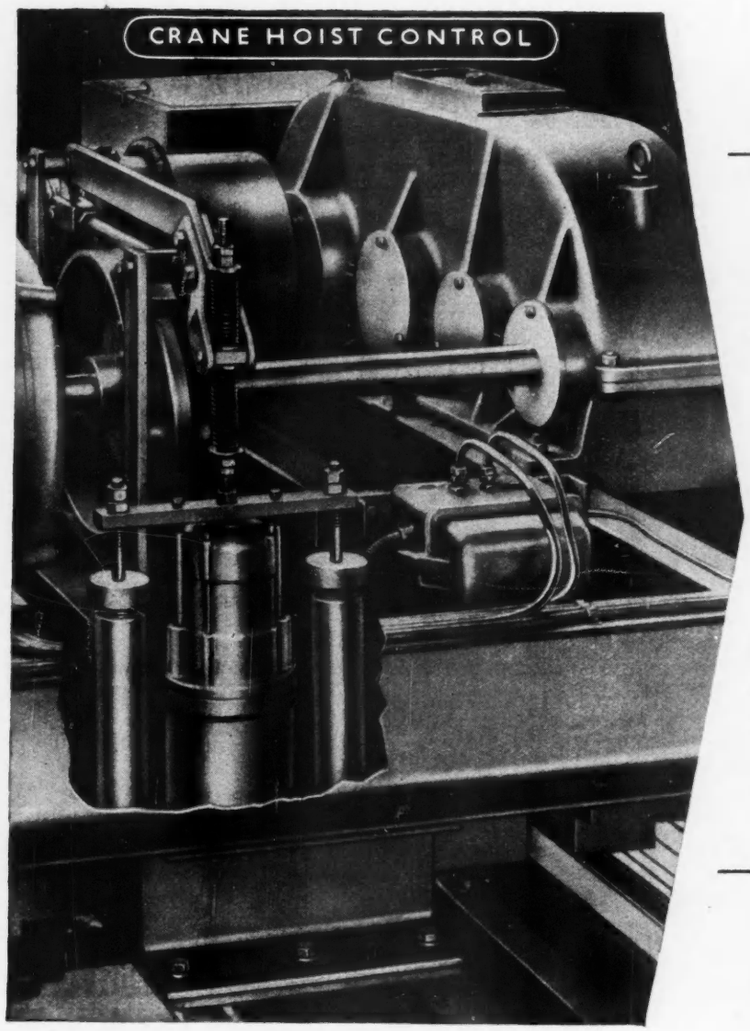


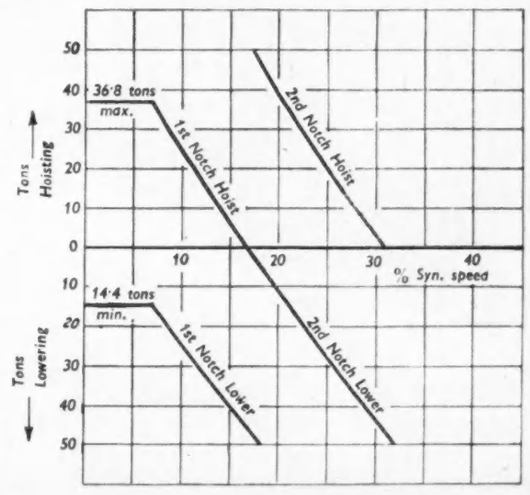
Inching is eliminated by *Stacreep control

*** A thrustor-operated brake is used with a wound rotor induction motor to provide a stable creeping speed on load. The creeping feature is arranged to occur on the first one or two notches on a drum controller.**

CREEPING PERIOD

1 Main motor is started ; thrustor motor which is energised from the main motor slip rings receives full line frequency and the thrustor lifts the brake.
2 Main motor accelerates but rotor frequency falls.
3 The speed of thrustor motor drops and the brake is gradually applied until Load Torque + Braking Torque = Motor Torque at a stable creep speed.

For further details, send for descriptive leaflets 12/4e-1



Creep speeds obtained at various loads.

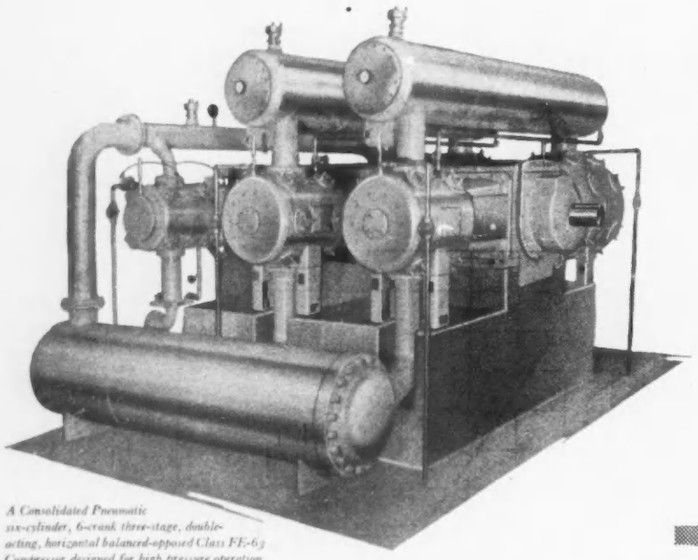
ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

MOTOR & CONTROL GEAR DIVISION RUGBY & MANCHESTER, ENGLAND

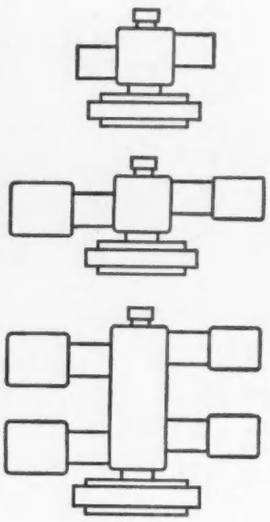
INCORPORATING THE MOTOR & CONTROL GEAR INTERESTS OF BTH & M-V

The adaptability of Standard "FE" compressor units brings you AIR AT LOWER COST * up to 5000 c.f.m. or 3000 p.s.i.

* *Class "FE" compressors are suitable for handling gasses other than air.*



A Consolidated Pneumatic six-cylinder, 6-crank three-stage, double-acting, horizontal balanced-opposed Class FE-63 Compressor designed for high pressure operation.



1. The basic Class "FE" crankcase and running gear, showing also compactness achieved by using engine-type, salient-pole motor.

2. Different-size cylinders can be fitted, one-, two-, three- or four-stage machines being available.

3. Large outputs are obtained by increasing the number of cylinders and working off a common crankshaft.

The advantage of standard Consolidated Pneumatic "FE" class compressor units is that they can be built up into single or multi-stage installations giving outputs up to 5,000 c.f.m. or pressures up to 3,000 p.s.i. to suit *exact individual* requirements, thus giving the most efficient return in terms of air delivered for power consumed. And, because the machines consist of standard units, the basic engineering cost of the plant as a whole is lower. Further, the virtues of the balanced-opposed design of these units are such as to effect considerable savings in foundation work, floor space and maintenance costs. In every way, "FE" compressors mean air at lower cost.

Advantages of the balanced-opposed design

In the "FE" compressors, the crankcase and frame are centrally positioned with cylinders on opposing sides, the drive being obtained by a double-throw crankshaft. The resulting perfect dynamic balance makes for far greater compactness and virtual freedom from vibration, space and foundation work being reduced to a minimum. Also, the considerably smaller load imposed on main bearings, together with slow operating speed, ensure an extremely long life of continuous operation with very little maintenance.

FOR FURTHER INFORMATION complete this form and pin it to your letter heading.

Consolidated Pneumatic

Makers of air compressors and 480 different models of power tools

CONSOLIDATED PNEUMATIC TOOL COMPANY LIMITED, DAWES ROAD, LONDON, S.W.6.

This form will bring you a descriptive catalogue on Class "FE" Compressors, but if you would like advice on a projected plant, your enquiry can be dealt with more expeditiously if the following information can be provided:-

1. Output required in cubic feet per minute at intake pressure and temperature. .....
2. Intake temperature and humidity. .....
3. Intake pressure. .....
4. Discharge pressure. .....
5. Type of drive motor, voltage, etc. .....
6. Temperature of cooling water and type of cooling circuit. .....
7. Aftercooler, if required, and temperature of air at discharge from aftercooler. .....
8. Purpose for which compressor is to be used. .....

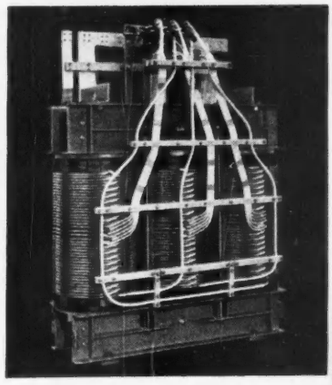
23

CP167

Large — medium — small

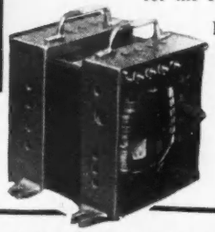
TRANSFORMERS

by Hackbridge



ABOVE: One of three 100 MVA 220 kV type ON transformers for Tasmania.

CENTRE: 1500 kVA distribution transformer for the Far East.



BELOW: Low power multipurpose unit.

23 MILLION KVA IN SERVICE

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Clean Feed Water

means higher boiler efficiency and lower fuel costs!

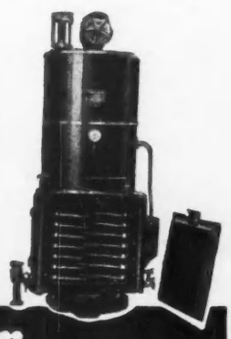
Feed water that deposits scale on boiler heating surfaces is a prime cause of overheating and subsequent tube collapse. And, remember, the majority of town water supplies, as well as sea-water, are heavy depositors of scale.

A Caird & Rayner Evaporator takes all the harm out of sea-water and provides a full supply of clean feed water to the boilers.

Not only is boiler efficiency raised and maintenance reduced appreciably, but substantial fuel savings will be seen as well.

Evaporators can be supplied to cope with feed water to any required rate. Further details will gladly be supplied on request.

EVAPORATORS AND CONDENSERS, FEED WATER HEATERS. FEED WATER FILTERS. EXHAUST STEAM OIL SEPARATORS. OIL FUEL HEATERS.



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HAMMERED OR HYDRAULIC PRESSED

FORGINGS

IN STEEL BLACK OR MACHINED TO 24 TONS

THE INCE FORGE CO. LTD.
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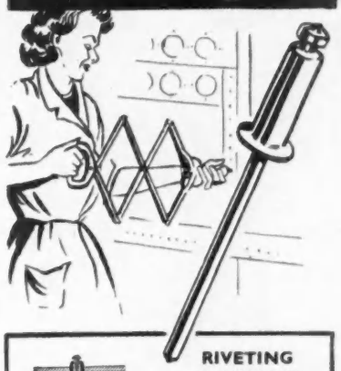
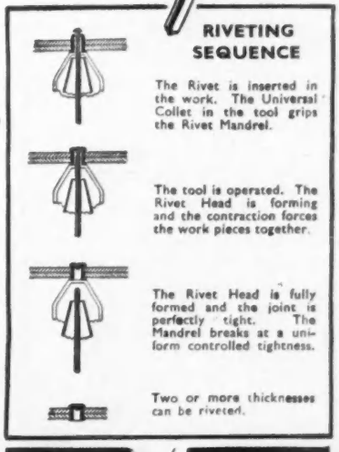
'POP' Regd. RIVETING

THE MODERN METHOD OF RIVETING

- ONE OPERATOR
- ONE OPERATION
- ONE SIDE ACCESS





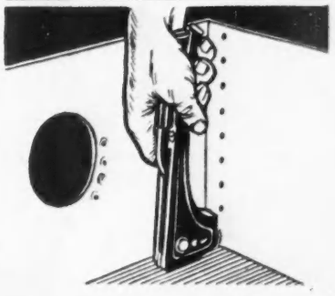
RIVETING SEQUENCE

The Rivet is inserted in the work. The Universal Collet in the tool grips the Rivet Mandrel.

The tool is operated. The Rivet Head is forming and the contraction forces the work pieces together.

The Rivet Head is fully formed and the joint is perfectly tight. The Mandrel breaks at a uniform controlled tightness.

Two or more thicknesses can be riveted.



"POP" Riveting is used in many industries on a variety of materials such as Aluminium, Steel, Plastics, Hardboard. Any combinations of these and other materials can be joined securely, neatly and economically.

Added thicknesses of material from .10in. to .50in. can be joined with "POP" Rivets.

RIVETING SYSTEMS LIMITED

KNOTT HOUSE,

JORDAN STREET, MANCHESTER 15

CENTRISPINNINGS

Engineers have long sought to produce components by a method which would combine the reliability of forgings with the economy which only castings can give.

The answer to the problem has been the evolution of Centrispinnings, which have soon proved their worth in an extremely wide range of applications. Innumerable applications remain and the process, developed in Firth-Vickers foundries, is so versatile that there must be many industries where such products would give excellent service and economy.

Advice, based on a unique fund of experience, together with technical data are available.

FIRTH-VICKERS STAINLESS STEELS LTD · SHEFFIELD

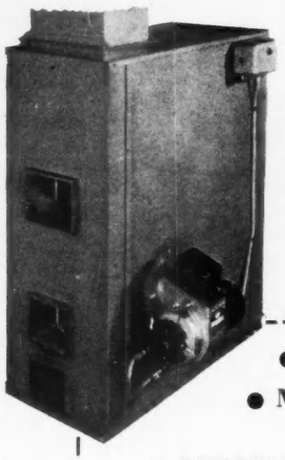
is the only Company in Europe to devote its activities exclusively to the production and development of stainless and heat-resisting steels.

TEMPERATURE STABILITY —all year round

achieved by the

HD 45 CLIMATHERM

WITH MINIMUM FUEL EXPENDITURE



Three way operation
Heater Ventilator Air Conditions

The HD 45 provides ideal working conditions throughout the entire year—circulates warm air in winter, cool air in summer. Write for full information on HD 45 now.

- SILENT OPERATION
- MAXIMUM FUEL ECONOMY
- THERMOSTATICALLY CONTROLLED

H. K. KUNZ LIMITED

LEVENBANK WORKS, ALEXANDRIA, DUNBARTONSHIRE

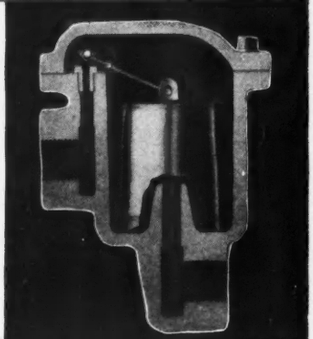
Tel: ALExandria 2561/2

"The Lancaster"

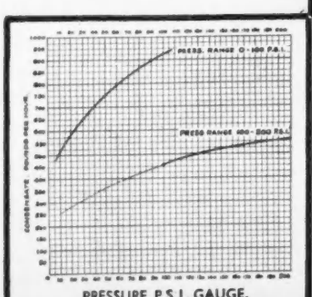
UNIT STEAM TRAP

A NEW TRAP BY AN OLD MAKER

... it's small, it's efficient, it's low in price.



MADE IN THREE SIZES: ½ in., ¾ in. and 1 in. B.S.P. or A.P.I.
Self-supporting on the pipe-line.



PRESSURE P.S.I. GAUGE.

Particularly suitable for use with Unit Heaters, Laundry Calenders, Tumblers, Presses, etc. Calorifiers, Heated Cavity Tables, Sterilisers and anywhere where unit trapping calls for a number of small inexpensive steam traps. PRESSURE RANGES: 0-100 P.S.I. sat. and 100-200 P.S.I. sat.

Graph opposite shows maximum continuous discharge at 10 deg. F. below steam temperature of ¾in. and 1in. trap. ½in. trap approximately half the discharge shown.

For further details ask for list No. 98.

Also manufacturers of "The Lancaster" EXHAUST HEAD, IMPACT STEAM SEPARATOR, PUMPING TRAP, and Steam Traps for all purposes.

LANCASTER & TONGE LTD

PENDLETON · MANCHESTER · ENGLAND

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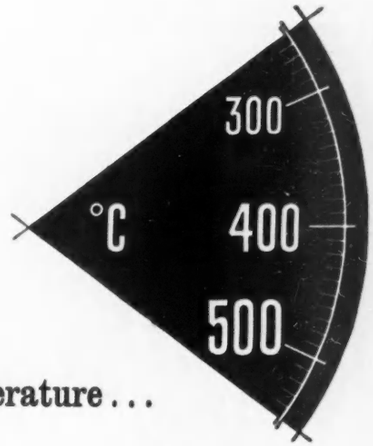
the ONLY effective lubricant at high temperature...



In 1959 such a claim for a product first marketed over 60 years ago may sound incredible. Yet it is demonstrably true: colloidal graphite (Acheson's of course) is the only effective lubricant for this temperature range. Oils, greases, synthetic fluids, in fact all other conventional lubricants are destroyed by such temperatures. "dag"* colloidal graphite does not merely survive; it continues to do its job efficiently.

The superfine particles of "dag" colloidal graphite will penetrate the finest clearances and provide a tough slippery film intimately bonded to the bearing surfaces. "dag" colloidal graphite can be incorporated in a conventional lubricant to impart a superior high temperature performance. For just one example, a low-carbon forming oil, with "Oildag"* colloidal graphite in oil added, becomes an effective conveyor chain lubricant in such equipment as bakery or enamelling ovens.

For even better results, however, we recommend using "dag" colloidal graphite in non-carbon forming carriers such as white spirit, glycol or water. One such product—"dag" Dispersion 504 (colloidal graphite in white spirit) is being used for lubrication and parting (at 800° C) between glass and formers on the vacuum flask equipment illustrated. Perhaps your high temperature problem can be solved the Acheson way too.

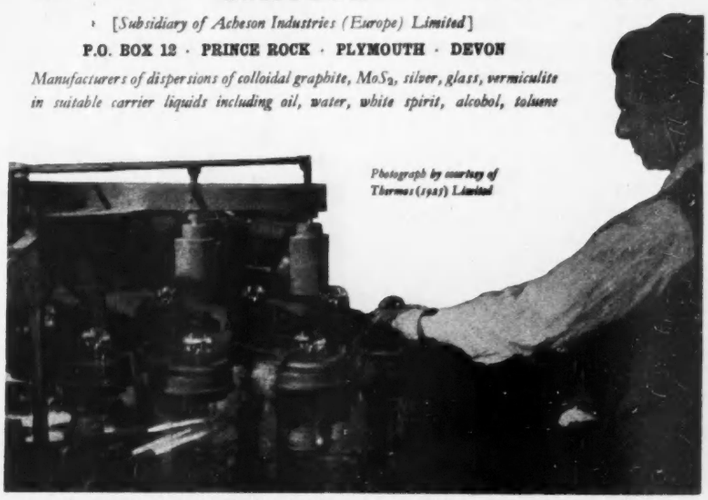
**Registered trade mark of Acheson Industries (Europe) Limited, licensed user— Acheson Colloids Limited*

Acheson Colloids LIMITED

[*Subsidiary of Acheson Industries (Europe) Limited*]

P.O. BOX 12 · PRINCE ROCK · PLYMOUTH · DEVON

Manufacturers of dispersions of colloidal graphite, MoS_2, silver, glass, vermiculite in suitable carrier liquids including oil, water, white spirit, alcohol, toluene



Photograph by courtesy of Thermos (1941) Limited

Also Acheson Colloiden N.V., Scheemda (Gr.) Netherlands & Acheson Colloids Company, Port Huron, Michigan, U.S.A.

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1959

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The Manager—
THE ENGINEER
28, ESSEX STREET, STRAND,
LONDON, W.C.2
CENtral 6565

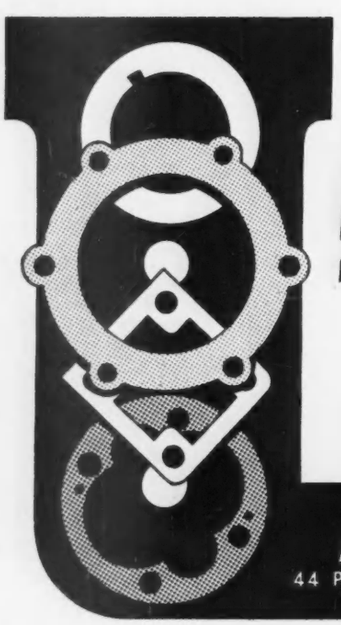
The Stanmil Company
DESIGN and SUPPLY for SPECIAL NEEDS
TRAILER STILLAGES
PALLETS CONTAINERS
HYDRAULIC LIFTS and
OTHER EQUIPMENT
for
MATERIALS HANDLING
ask us to call :—
BASING RD., BASINGSTOKE
Telephone : No. 551.

ODDIE FASTENERS
PAT. NO. 507249
THE GENERAL PURPOSE FASTENER FOR ENGINEERS.
Simple—Positive—Self Locking. Made in a variety of types and sizes. Special Fasteners to suit customers' requirements.
Used on aircraft, automobiles, coaches, caravans, rail coaches, electrical, radio and radar units, refrigerators, marine craft, display equipment, etc.
For quickly detachable doors, covers, panels, access covers, etc.
For full details and literature apply to
ODDIE BRADBURY & CULL LTD — PORTSWOOD RD. — SOUTHAMPTON
TEL: 55083 CABLES: FASTENERS, SOUTHAMPTON

Why waste time brushing smoke tubes, and rodding clinker and birds nesting, when a few minutes with a Percussion Lance will shift everything from Economisers, Airheaters, Water Tubes, Fire Tubes, etc.

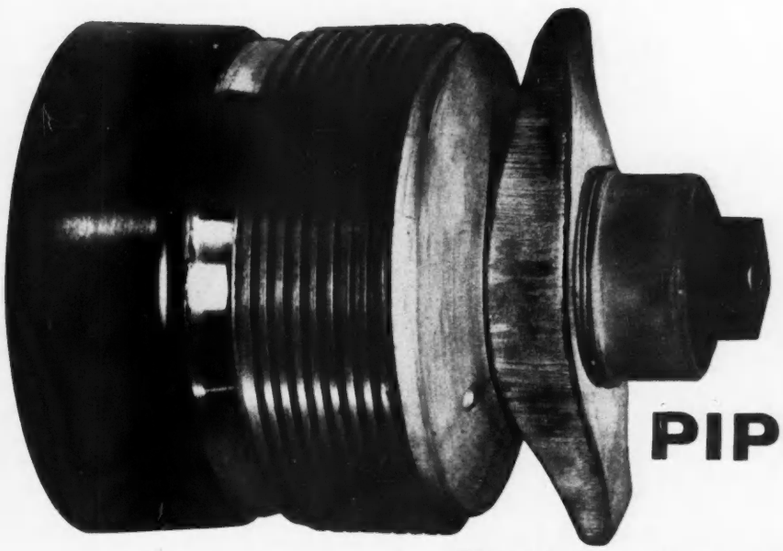
See this new cleaning tool in action at your own works— write to
AIRNESCO PRODUCTS LIMITED
KNIGHT ROAD, STROOD, ROCHESTER, KENT
Telephone: Strood 78310

AIRNESCO Percussion LANCE



ARTUS
PRECISION PLASTIC SHIMS
From ·0005" up to ·040".
"THE COLOUR TELLS THE THICKNESS"
There is an "ARTUS" grade for most Chemical and Thermal Conditions.
EASY TO IDENTIFY · EASY TO USE
* Write for Samples and Literature or Mail Blueprint for Quotation.
AUTO AERO LTD.
44 PACKINGTON ROAD LONDON W.3 Telephone ACORN 0544

AT LAST! An economical, safe and easy-to-use device for plugging open-ended pipes for pressure testing and pigging.



THE G.D. CONE LOCK PIPE STOPPER

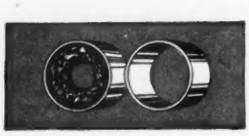
The higher the pressure, the tighter the stopper

Pressure testing of open-ended steel pipes and pipe fittings is considerably simplified with the aid of cone lock pipe stoppers. These tools are designed to withstand test pressures of up to 2000 lbs./sq. in. and can be used successfully for any application where a simple, efficient and re-usable seal is required. For further details, ask for our leaflet "Cone Lock Pipe Stoppers."

The cone lock pipe stopper in position.

The stopper is easily removed after testing by slackening the wing nut.

GENERAL DESCALING CO. LTD.



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Telephone: Worksop 3211/3

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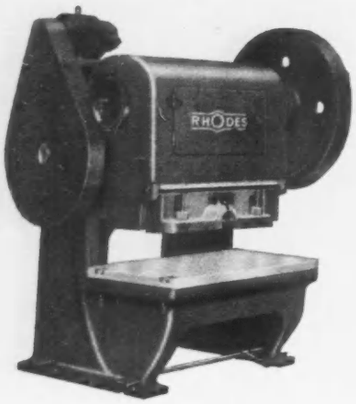
JOSEPH RHODES & SONS Ltd
Of WAKEFIELD ENG. Estab. 1824

THE SPECIALISTS IN PRESS CONSTRUCTION



SOUND · SOLID
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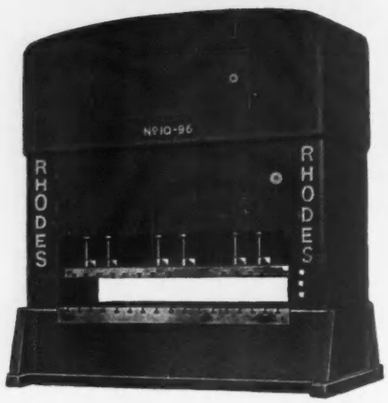
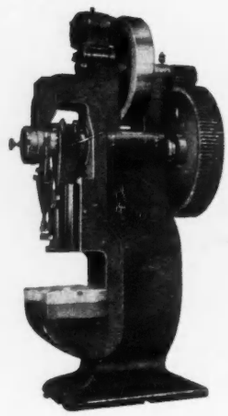
RELIABLE.





NO OTHER PRESSES CAN COMPETE WITH THEM

EVERYTHING IN SHEET METAL WORK
GENERAL ENGINEERING

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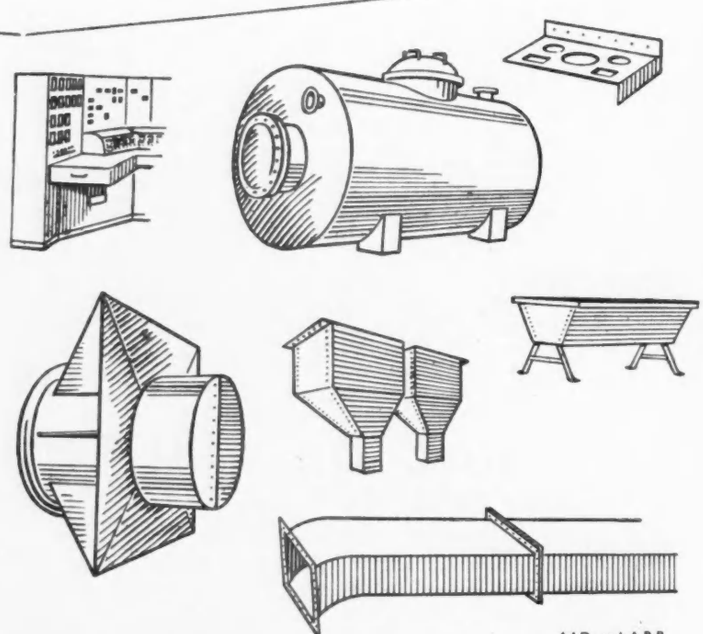
V. W. CO., LTD.

FOR FABRICATION and GENERAL ENGINEERING

General Sheet Metal Work, Metal Pressing and Stamping, Duct Work and Ventilating Plants, Tanks Cylinders Turning Milling etc. PLATING, Chrome, Nickel, Cadmium etc.



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Radspray Works, High Street, Stratford, London, E.15 Tel: MARyland 6761 (6 lines)
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INDUSTRIAL WATER TREATMENT

FILTERS
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(Chemical Pumps, Gravity Solution Dosers, Dry Feeders)

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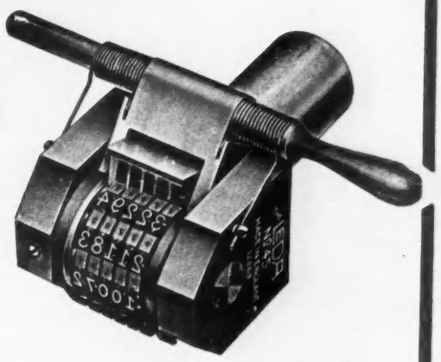
"LEDA" NUMBERING MACHINES

NUMBERING HEAD for METAL



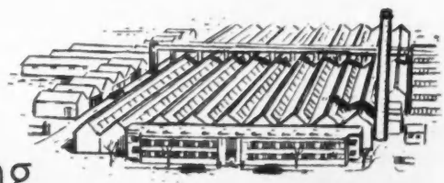
Consecutive and Repeat actions

Power, Fly, Hand or Pneumatic Presses and similar equipment

It is used for marking Aircraft components with reference numbers, part and drawing numbers, date of manufacture, inspection mark for marking Shells, Bombs, Cartridges, Engine Parts, Motor Car, Motor Cycle, Cycle, Wireless, Electrical, Clock, Watch and other instrument parts in all materials. Checks Labels, Name Plates, Pigeon Rings, in fact, any article which requires an identification mark. Massed produced articles can only be satisfactorily identified by individual reference number.

W LETHABY & Co. LTD
LEDA HOUSE, 124-132 CLERKENWELL ROAD, LONDON, E.C.1
Telephone: Terminus 1104 (3 lines)

five
very good reasons for using
VOLEX air heaters



1. Volex Heaters can be fitted with Oil Burners to burn ANY GRADE OF OIL.
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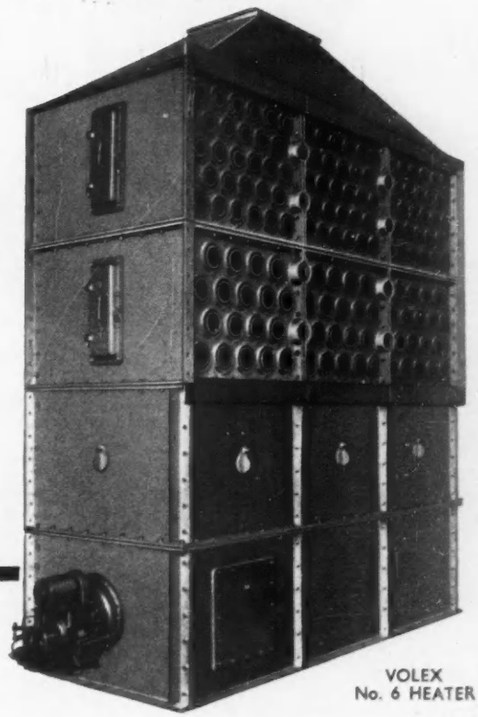


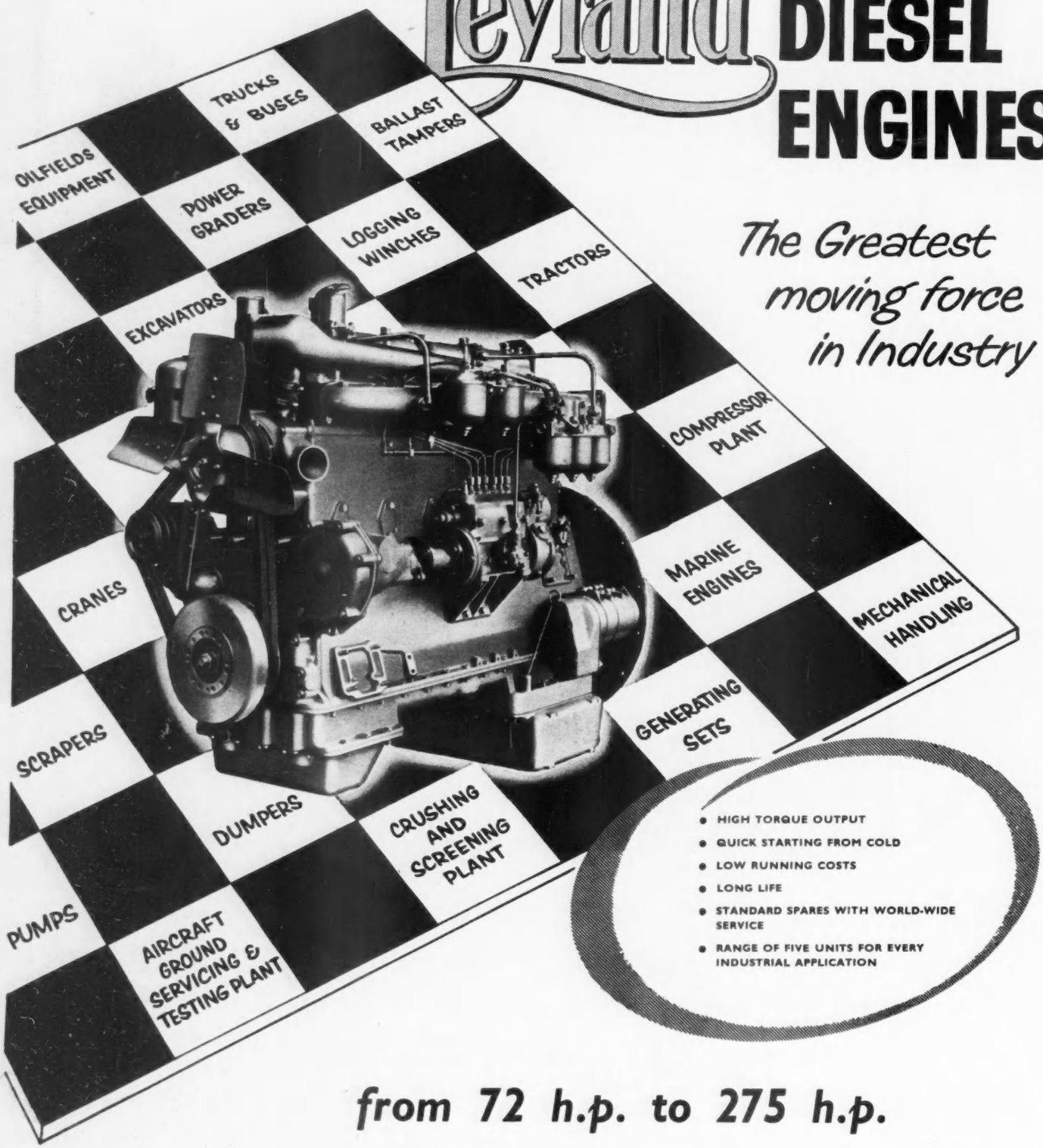
VOLEX No. 6 HEATER

Send for full details to the Sole Makers:
T. E. SALTER LTD.,
BLOOMFIELD, TIPTON, STAFFS
Phone: TIPton 1657/8

The answer to every power problem ...

Leyland DIESEL ENGINES

The Greatest moving force in Industry



- HIGH TORQUE OUTPUT
- QUICK STARTING FROM COLD
- LOW RUNNING COSTS
- LONG LIFE
- STANDARD SPARES WITH WORLD-WIDE SERVICE
- RANGE OF FIVE UNITS FOR EVERY INDUSTRIAL APPLICATION

from 72 h.p. to 275 h.p.

LEYLAND MOTORS LIMITED

Sales Division: HANOVER HOUSE HANOVER SQUARE · LONDON, W.1 · Telephone: MAYfair 8561

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and pro rata. 12 lines to 1 inch. There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and pro rata. 12 lines to 1 inch There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page. (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

UNIVERSITY OF SHEFFIELD

DEPARTMENT OF ARCHITECTURE

CHAIR OF BUILDING SCIENCE

Applications are invited for a newly-created CHAIR OF BUILDING SCIENCE in the Department of Architecture, to begin duties as soon as possible.

In seeking a Professor of Building Science, the University is looking for a candidate who has been trained in some branch of science and has subsequently had experience in a relevant field relating to building, such as, for example, Building Materials, Building Services or the Physics of Environment. Alternatively, he might be an Architect with special interest in an experience of scientific aspects of the subject.

Salary, £2450 a year, with F.S.S.U. provision and family allowance.

Further particulars should be obtained from the Registrar, to whom applications (20 copies—one only from overseas candidates) should be sent by 17th October, 1959. E7155

UNIVERSITY OF BRISTOL

DEPARTMENT OF CIVIL ENGINEERING

LECTURESHIP

Applications are invited for a LECTURESHIP (Grade III or II) in the Department of Civil Engineering. Applicants should have a good Honours Degree and some practical experience, preferably in the field of structural steelwork. It is desirable that candidates should be under 35 years of age and have some teaching experience.

Salaries will be in accordance with the following scales :—

Assistant Lecturer (Grade III), £700–£850.

Lecturer (Grade II), £900–£1300 (bar)–£1650.

The appointment is to be made as soon as possible and the successful candidate will be required to take up duty not later than the 1st January, 1960.—Applications, including the names of two persons to whom reference may be made, should be sent to the Registrar, The University, Bristol, 8, from whom further particulars may be obtained. E7192

UNIVERSITY OF LEEDS

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER

Applications are invited for appointment as LECTURER in the Department of Electrical Engineering, from January 1st, 1960. Candidates should have good academic qualifications and experience in the field of electric power engineering, preferably electrical machines. Salary will be on the scale £900 by £50 to £1350 (efficiency bar) by £75 to £1650 a year.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than 1st October, 1959. E7162

CEMENT AND CONCRETE ASSOCIATION

LECTURERS IN CONCRETE TECHNOLOGY

The Cement and Concrete Association invites applications for appointments as LECTURERS IN CONCRETE TECHNOLOGY.

Applicants should have appropriate technical qualifications with sound, practical experience of concrete construction. The appointments will involve close contact with current civil engineering practice and may provide opportunities for research.

Applications, together with details of qualifications and experience, to The Principal, C & CA Training Centre, Wexham Springs, Framewood Road, Stoke Poges, Bucks. E7174

PUBLIC APPOINTMENTS

UNIVERSITY OF MELBOURNE

READER OR SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above position.

The salary ranges are £A2560 to £A2800 per annum for a Reader and £A2200 to £A2550 per annum for a Senior Lecturer. Commencing salary will be fixed according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Further particulars may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 2nd October, 1959. E7150

ST. EDWARD'S MENTAL HOSPITAL

CHEDDLETON, Nr. LEEK, STAFFS
(1395 BEDS)

SUPERINTENDENT ENGINEER AND CLERK OF WORKS REQUIRED

Salary £890 to £1045. Applicants must be competent to undertake the responsibility of the satisfactory maintenance and co-ordination of the hospital's engineering services, including both mechanical and electrical. Must have passed an examination in engineering technology and hold one of the following qualifications :—

Higher National Diploma (or Certificate) in Mechanical Engineering.

First Class Certificate of Competency in Marine Engineering or equivalent Naval Certificate.

City and Guilds Full Technological Certificate in Plant Engineering.

Must be competent to undertake the duties of Clerk of Works of the Building Maintenance Department in all its branches. The person appointed will be required to reside in the house provided on the hospital estate, for which a rental will be charged.—Applications, with full details of training, experience and certificates held, with names of two referees, by 5th September, 1959, to The Group Secretary. E7181

MINISTRY OF SUPPLY

MOTTINGHAM

QUANTITY SURVEYOR'S ASSISTANTS

Ministry of Supply requires QUANTITY SURVEYOR'S ASSISTANTS at Mottingham for squaring dimensions, checking dimensions and abstracts, assisting in checking contractors' accounts, preparing estimates for minor services, abstracting and preparing bills of quantities, and technical details associated with Quantity Surveyor's office. Qualifications : Recognised engineering apprenticeship and considerable experience in Quantity Surveyor's office. Extensive experience in the use of War Department Schedule an advantage. O.N.C. in Building, C. & G. Final Certificates in Quantities, or equivalent qualification desirable. Salary : £720 (age 26) to £900 p.a.—Application forms from Manager (PE 2019), Professional and Executive Register, M.O.L. & N.S., Farringdon Street, London, E.C.4. E7202

NORTHERN IRELAND HOSPITALS AUTHORITY

SENIOR ASSISTANT ENGINEER (MECHANICAL)

SENIOR ASSISTANT ENGINEER (MECHANICAL) required on the staff of the Chief Engineer's Department of the Authority's Headquarters.

Applicants should be Corporate Members of the Institution of Mechanical Engineers, with wide experience in the design and operation of heating, hot water and ventilating systems, and/or boilerhouse and associated engineering services in buildings.

Salary : £1050 by £30 (3) by £35 (3) to £1245 per annum.

Application forms from Secretary, Northern Ireland Hospitals Authority, 27, Adelaide Street, Belfast, for return by 11th September, 1959.

Preference will be given to candidates who served in H.M. Forces in war-time.

Canvassing disqualifies. E7175

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Vacancies for SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in following localities :

LONDON AREA : MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles : knowledge of theoretical hydrodynamics and theory of control systems an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICISTS for acoustic analysis. ELECTRONIC PHYSICISTS for data handling and analysis problems. PHYSICIST interested in operator performance. CLASSICAL PHYSICISTS.

BALDOCK : PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH : ELECTRONIC ENGINEERS for research on analogue computers and transistor circuits. ELECTRICAL ENGINEERS for research on small rotating electrical machinery. PHYSICISTS—for optical systems and instrumentation. ELECTRO-MECHANICAL ENGINEERS — for work on servo-mechanisms.

PORTLAND : PHYSICISTS or APPLIED MATHEMATICIANS for research on underwater acoustics. ELECTRONIC PHYSICISTS, ELECTRONIC ENGINEERS—for design work. PHYSICAL CHEMISTS.

POOLE : CHEMICAL ENGINEERS. CHEMISTS for work on rubber technology.

ROSYTH : PHYSICISTS—(Electronic).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Hons. Degrees, S.S.Os. must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) : S.S.O., £1233–£1460 ; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.220/9A). E7037

BRITISH RAILWAYS RESEARCH DEPARTMENT

ENGINEERING DIVISION, DERBY

SCIENTIFIC OFFICER, GRADE 2

Vacancy for SCIENTIFIC OFFICER, Grade 2, Engineering Division, Derby.

Initially to study problems connected with dynamics of trains, shocks to goods in transit, &c. Candidates should have good Degree. Previous experience of research not essential. Consideration given to candidates about to take their Degree, engagement being subject to their subsequent passing of required standard.

Salary : £665 to £985 per annum (according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications, stating age, experience, &c., to :—Director of Research,

British Railways Research Department,
222, Marylebone Road,
London, N.W.1. E7165

ADMIRALTY

ASSISTANT TO HEAD OF TRAINING

ASSISTANT TO HEAD OF TRAINING (Department of Dockyards and Maintenance). Post at Bath for man with practical experience in organisation and presentation of training programmes at all levels of management, preferably in the engineering industry. Professional qualifications desirable. Considerable travelling involved. Appointment initially for three years. Salary in the range £1600 to £1800, according to qualifications and experience. —Write for application form to Admiralty C.E.II (114), Empire Hotel, Bath. Closing date, 18th September, 1959. E7180

PUBLIC APPOINTMENTS

THURROCK URBAN DISTRICT COUNCIL

(POPULATION 110,000—RAPIDLY INCREASING)

ENGINEER AND SURVEYOR'S DEPARTMENT

APPOINTMENTS

(a) ASSISTANT ENGINEER. Salary : A.P.T. IV, £1065 to £1220 per annum. Applicants should be Chartered Civil or Municipal Engineers, or have equivalent qualifications and have extensive civil engineering experience, and should be capable of designing and supervising construction of major schemes. In particular, experience is desired in sewerage and sewage disposal. Housing accommodation may be considered if successful candidate resides more than 20 miles from Thurrock.

(b) Two ENGINEERING ASSISTANTS. Salary : A.P.T. I/II, £610 to £880 per annum. Applicants should have completed their training in a Municipal or Civil Engineers' office and have had some subsequent experience.

Appointments pensionable.

Applications, stating age, qualifications and experience, and quoting three referees, to the Clerk of the Council, Council Offices, Grays, Essex, by 8th September, 1959. Canvassing disqualifies. Relationship with members or senior officers of the Council must be disclosed. E7149

SURREY COUNTY COUNCIL

HIGHWAYS AND BRIDGES DEPARTMENT

APPOINTMENTS

Surrey County Council Highways and Bridges Department have vacancies for :—

(a) CIVIL ENGINEERS
Appointments provide first-class experience in new bridge and road design and construction. One Engineer is required for design of major river improvement schemes.

(b) ENGINEERING ASSISTANTS
Appointments provide suitable experience for those proceeding to a professional qualification.

(c) RESIDENT ENGINEER
For a period of approximately 20 months, to supervise construction of road and reinforced concrete bridge works by contract. Salary : £1400 per annum.

SALARY RANGES for :

(a) between £785 and £1375 per annum, and
(b) between £610 and £1065 per annum,
plus London Allowance.

Particulars and forms of application returnable by 19th September, 1959, from County Engineer, County Hall, Kingston-upon-Thames. E7159

BRIGHTON CORPORATION WATERWORKS

WATERWORKS DEPARTMENT

ASSISTANT ENGINEER

Waterworks Department have vacancies for ASSISTANT ENGINEER, Grade A.P.T. III (£880–£1065), ENGINEERING ASSISTANTS, Grade A.P.T. II (£765–£880) and Grade A.P.T. I (£610–£765).

Suitably qualified applicants should have good general waterworks experience. Appointments are superannuable, terminable by one month's notice on either side and subject to medical examination. Fifty per cent of removal expenses refunded.

Application forms from the Waterworks Engineer, 12, Bond Street, Brighton, 1, to be returned to him suitably endorsed by 5th September, 1959.

W. O. DODD,
Town Clerk.
Town Hall,
Brighton, 1. E7126

Classified Advts. continued on page 136

PUBLIC APPOINTMENTS

UNITED CAMBRIDGE HOSPITALS

ADDENBROOKE'S HOSPITAL

SENIOR ENGINEER

SENIOR ENGINEER required at Addenbrooke's Hospital, to work under general supervision of Group Superintendent Engineer. Whitley Council conditions and salary (10½–20 points), £680 by increments to £815.

Candidates must possess a sound knowledge of steam boiler plant operation and have a wide experience of mechanical and electrical engineering services.

Successful applicant will be required to live near the hospital and a house is available for rent if wanted.

Applications in writing, giving age, training, experience, qualifications and names of 2 referees, to the Secretary, Addenbrooke's Hospital, Trumpington St., Cambridge, by 12th September, 1959. E7167

TENDERS

STATE ELECTRICITY COMMISSION OF VICTORIA,

23-32, WILLIAM STREET, MELBOURNE VICTORIA, AUSTRALIA

BUCKET WHEEL DREDGER—MORWELL OPEN CUT

The Commission is inviting TENDERS for the MANUFACTURE, SUPPLY, DELIVERY and ERECTION,

ALTERNATIVELY :

MANUFACTURE, SUPPLY and DELIVERY only, of :—

ONE Electrically operated BUCKET WHEEL DREDGER capable of an overall output of 1500 tons per hour, all in accordance with the terms and provisions of Specification No. 59–60/8 and B.6 ; alternatively, A.7 Contract Conditions.

Copies are available from the Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2, and also from the Commission's Offices, 22, William Street, Melbourne, Australia.

The charge for specification is :—

£3 (returnable) for 3 sets of Tender documents. Extra copies, £1 (not returnable) per set.

Tenders endorsed " Tender to Specification No. 59–60/8," are returnable in the Tender Box, Ground Floor, 22, William Street, Melbourne, Victoria, by 11 a.m. on the 23rd December, 1959.

The Commission does not bind itself to accept the lowest or any Tender. E7104

INDIA SUPPLY MISSION

WASHINGTON, D.C.

The India Supply Mission, Washington, D.C., invites TENDERS for the SUPPLY of :—

	Description of Equipment	Enquiry No.	Closing Date
	S.3410/59 (CDN)		
1.	Bulk Sterilizer and Sterilizing Autoclaves	SE–77	15th Sept., 1959
2.	Blowers	SE–78	17th Sept., 1959
3.	Gas Burners, Furnace Blowers, Silica Trays	SE–79	15th Sept., 1959
4.	Sterile cubicle and air operated loader	SE–80	15th Sept., 1959
5.	Turbo Compressors	SE–82	22nd Sept., 1959
	S.3411/59 (CDN)		
6.	Refrigerator Equipment for Chilled Water System	SE–83	1st Oct., 1959
7.	Ejectors	SE–85	1st Oct., 1959
8.	Separators and Filters	SE–86	6th Oct., 1959
9.	Glass Wool	SE–87	6th Oct., 1959
10.	Air After - Coolers, Heaters and Reheaters	SE–88	1st Oct., 1959
	S.3422/59 (CDN)		
11.	Rod and Pulverising Mills	SE–90	8th Oct., 1959
12.	Scrubbers	SE–92	8th Oct., 1959
13.	Glass lines agitating and crystallisation tanks and reaction vessels	SE–93	13th Oct., 1959
14.	Vacuum Pumps	SE–94	15th Oct., 1959
15.	Vibrators	SE–95	8th Oct., 1959
16.	Pipes for steam of low and moderate pressure, compressed air, process water, chilled water and vacuum	SE–98	20th Oct., 1959

Forms of Tender may be obtained from the India Store Department (CDN Branch), Government Building, Bromyard Avenue, London, W.3, upon a payment of a fee of 14s. 3d. per Tender, which is not returnable. The relevant Enquiry No. and S. file No. must be quoted in all applications. E7168

BUCKS WATER BOARD

MID BUCKS SCHEME

Applications are invited from actual manufacturers of STEEL PIPES who desire to be considered for inclusion on an approved Tender List, all in accordance with the Board's Standing Orders, Conditions of Contract and Specifications.

Applicants must state if they are willing to consider fixed price tenders and they should note that all goods and materials are to be British (including Commonwealth) and carried in British ships and that only selected applicants will be invited to tender.

Applications must be received by the undersigned not later than noon on Tuesday, 8th September, 1959, and each envelope shall be clearly endorsed "Steel Pipes."

H. A. FOLEY,
Clerk of the Board.

7, Temple Square,
Aylesbury.
17th August, 1959. E7166

TENDERS

COUNTY BOROUGH OF SWANSEA

WATER DEPARTMENT

PRIMARY DISTRIBUTION SYSTEM—EASTERN AREA CONTRACT 5

The Corporation invite TENDERS from experienced Contractors for the LAYING of approximately 3150 yards of SPUN IRON and STEEL WATER MAINS, 24in. and 27in. diameter, between Morriston and Bonymaen, Swansea.

Copies of the specification, bill of quantities, form of Tender and drawings may be obtained from the Borough Water Engineer and Manager, The Guildhall, Swansea, on deposit of two guineas, which will be refunded on the submission of a bona-fide Tender (not subsequently withdrawn) and the return of the above-mentioned documents.

Tenders, in plain, sealed envelopes, with no indication of the sender, endorsed " Water Department—Contract 5," may be sent by registered post or delivered by hand, in exchange for a receipt, to the undersigned on or before Saturday, 19th September, 1959.

The Council does not bind itself to accept the lowest or any Tender.

T. B. BOWEN,
Town Clerk.

The Guildhall,
Swansea,
19th August, 1959. E7194

INDIA STORE DEPARTMENT

Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for :

	Quantity, tons
ALLOY STEEL BARS ROUND, ⅜in. dia.	1,424
STEEL BARS ROUND, 1in. dia.	42,316

Forms of Tender may be obtained from the above address at a fee of 10s., which is not returnable.

If payment is made by cheque, it should please be made payable to " High Commission for India." Tenders are to be delivered by 2 p.m. on 8th October, 1959.

Please quote reference No. 10/59/RLY. E7179

INDIA STORE DEPARTMENT

The Director-General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites tenders for the supply of :

TENDER REF. NO 20036/59/HSK/HAL
NICKEL " F " SHOTS 89 to 92 NICKEL APPROX. 7 TONS FOR PRODUCTION OF ALLOY CAST IRON.

The Tender forms with schedules and specifications which are returnable on 28th September, 1959, may be obtained from the above office (C.D.N. Branch) on payment of a fee of ten shillings (NOT refundable) for each tender. The applications for tenders should clearly state the above reference number. E7169

EDUCATIONAL

THE POLYTECHNIC,

309, REGENT STREET, W.1

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

Head of Department : B. FERGUSSON, B.Sc. (Eng.), Ph.D., A.M.I.Mech.E.

PART-TIME DAY and EVENING COURSES are held for the award of Ordinary and Higher National Certificates in Civil and Mechanical Engineering.

Courses are also held in Engineering Workshop Practice.

Session begins on 28th September, 1959. New students will be enrolled on Wednesday, 23rd September, 5–8 p.m.

Prospectus may be obtained on application to the DIRECTOR OF EDUCATION. E7154 E

COLLEGE OF AERONAUTICS

A SHORT COURSE ON

AIRCRAFT GAS TURBINE THEORY AND DESIGN

will be held at the College from Monday, 2nd November, to Friday, 20th November, 1959.

The Course will deal mainly with performance, systems, turbo-machine aerodynamics and related design topics, but will include some experimental work on engines.

Fees for the course are £70, inclusive of full board and residence.

Further details and copies of the syllabus may be obtained on application to The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E7176 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

ELECTRONICS, covering practical and theoretical aspects, basic principles, industrial applications, electronic apparatus, &c. Guaranteed coaching for Brit.I.R.E., City and Guilds, &c. Study at home under highly qualified tutors.—Write for free book : International Correspondence Schools ,71, Kingsway (Dept. 446A), London, W.C.2. E157 E

EDUCATIONAL

UNIVERSITY OF MANCHESTER

THE NEXT SESSION COMMENCES ON TUESDAY, 13th OCTOBER, 1959. E7029 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A LARGE CONCERN operating in the North of England and based upon Newcastle upon Tyne is making extensive use of the latest forms of telecommunications/control in its own internal services. An advisory appointment of two years duration only, preferably but not necessarily upon a full-time basis, is to be made. An attractive remuneration will be offered to a person qualified to advise upon and co-ordinate these developments.—Applications to BOX No. E7197, " The Engineer." A

ASSISTANT WORKS MANAGER. The successful applicant will have had varied experience in light engineering, M/C shop, press shop and small mechanisms assembly, be a keen disciplinarian and able to control a labour force of several hundred. Only those who possess the initiative, drive and personality to fill this post, which carries a good salary and prospects with pension entitlements, should write, giving full particulars, to Personnel Manager, Roneo, Limited, Romford, Essex. E6997 A

BRONX ENGINEERING COMPANY, LTD., DUDLEY ROAD, LYE, have the following vacancies in their Machine and Tool Design Offices :

(a) SENIOR DESIGNER with design experience of auxiliary machines for Ferrous and Non-Ferrous Sheet and Tube Mills. For this responsible position comprehensive experience of special purpose machinery design and a good technical standard coupled with a high sense of personal responsibility are essential.

(b) SENIOR AND INTERMEDIATE DESIGNERS for the Tool Design Office. Experience of tool design in the field of Press Brake Work would be the prime qualification, but men having a good technical and practical training combined with drive, initiative and the ability to work as a member of a small highly skilled and enthusiastic team could qualify.

(c) INTERMEDIATE DRAUGHTSMEN with good practical and technical qualifications preferable with experience of detail design of special purpose machines. This is an excellent opportunity for young men of considerable ability to further their career by working with a team of highly specialised designers.

REPLIES, STATING QUALIFICATIONS (which will be treated in the strictest confidence) should be addressed to :

THE CHIEF DESIGNER, BRONX ENGINEERING COMPANY, LTD., DUDLEY ROAD, LYE, Near Stourbridge, Worcs. A7083 A

SITUATIONS VACANT

BUSH RADIO LIMITED

wish to recruit a GRADUATE ENGINEER (MECHANICAL OR ELECTRICAL). Academic qualifications are of less importance than qualities of character, tact and drive. Full training and experience will be given with a view to a senior Works appointment, probably in the Company's Plymouth factory, in due course.—Apply by letter, with full particulars of career so far, to the Personnel Adviser (B 126), The Rank Organisation, 11, Belgrave Road, London, S.W.1. E7151 A

COMPRESSOR ENGINEER required by contracting company to the Petroleum and Chemical Industries. Applicants should preferably have a University Degree in Engineering, together with at least 5 years' experience in the design and manufacture of both reciprocating and centrifugal compressors on air and gas service. Some experience with steam and gas turbines is also desirable but not essential. Please write, stating briefly age, qualifications and experience.—BOX No. E7153, " The Engineer." A

DESIGN DRAUGHTSMEN, for interesting work on mechanical devices for the Building Industry. Winch experience an advantage.—Write, including full details of experience and qualifications to Chief Engineer, A.B. MOULD AND CONSTRUCTION CO. LTD., VULCAN WORKS, VULCAN WAY, NEW ADDINGTON, SURREY. E2525 A

DESIGNER-DRAUGHTSMAN required for the design and development of manufacturing plant and special-purpose machines. Previous experience essential. It would be an advantage to possess H.N.C. Starting salary up to £950, according to qualifications.—Apply, in writing, giving full details, to The Personnel Manager, The Micanite and Insulators Company, Ltd., Empire Works, Blackhorse Lane, Walthamstow, E.17. E7188 A

DESIGNER-DRAUGHTSMAN required, preferably with H.N.C. in Mechanical Engineering. Non-contributory pension scheme available.—Applications to Metalectric Furnaces, Ltd., Cornwall Road, Smethwick, 40, Staffs. E2512 A

DRAUGHTSMAN required. Experience in mechanical handling plant and structures an advantage. Good prospects.—British Industrial Sand, Ltd., High Street, Godstone, Surrey. E161 A

DRAUGHTSMAN required for work on valve design. All applications will be treated in strict confidence.—Apply in writing to Chief Engineer, Alley and MacLellan, Ltd., Bromyard Road, Worcester. E7170 A

DRAUGHTSMAN experienced in designing rubber and plastic hydraulic presses.—Apply to T. H. Dixon and Co., Ltd., Works Road, LETCHWORTH, HERTS. E2523 A

BOOKS and PUBLICATIONS

PITMAN
TECHNICAL BOOKS

FROM ALL BOOKSELLERS

Parker St., Kingsway, London, W.C.2.

MODERN ELECTRONIC COMPONENTS

By G. W. A. Dummer, M.B.E., M.I.E.E., etc. The first comprehensive book of its kind to be published in the world. It presents a comprehensive survey of the characteristics of the more common components, together with information on their behaviour under the arduous environmental conditions to which they are now frequently subjected. 55s. net.

SOLUTION OF PROBLEMS IN THEORY OF MACHINES

By S. Anvoner, B.Sc., A.M.I.Mech.E. This book contains 488 examples, of which 203 are fully worked out and the remainder left as exercises for which answers are provided. Intended for H.N.C. exams in engineering; the B.Sc. (Eng.), London, and the final degree exams at other universities; and the Diploma in Technology exams. 35s. net.

ANALYSIS OF PIPE STRUCTURES FOR FLEXIBILITY

By John Gascoyne, A.F.Inst.Pet. A new book for piping designers and designer-draughtsmen which deals with specialized piping design for high-temperature and high-pressure use where the ordinary procedures do not apply. This has particular application to petroleum refineries, petro-chemical and other chemical industries, feed-systems for electricity and nuclear power stations, etc. 45s. net.

HMSO

Hydraulic Research Papers

The first two papers in a new series describing the successful attempts of the Hydraulics Research Station, Wallingford, to simplify the application of the complex Colebrook-White equation. A set of design charts for channels and pipes has been evolved, expressed in terms of the engineering variables of discharge, hydraulic gradient, pipe or channel dimensions, and velocity. With them a direct solution to almost any problem of fluid resistance can be obtained. Of the two papers, the first reviews the principles of turbulent resistance and describes the derivation of the new design method, and the second contains the charts themselves. Both are the work of Mr. Peter Ackers.

No. 1 : **Resistance of fluids flowing in channels and pipes. 8s. 6d.** (*post* 5d.)
No. 2 : **Charts for the hydraulic design of channels and pipes. 12s.** (*post* 6d.)

From the Government Bookshops or through any bookseller

HMSO

JOHN BROWN AND COMPANY LIMITED

Engineers and Shipbuilders

MORE COMPETITIVE TRADING CONDITIONS

PROFITS BETTER THAN FORECAST

LORD ABERCONWAY'S REVIEW

The ninety-fifth Annual General Meeting of John Brown and Company Limited will be held on October 2nd at 4, The Sanctuary, Westminster, London, S.W.1.

The following is the Statement by the Chairman, **The Right Hon. Lord Aberconway,** which has been circulated with the Report and Accounts for the year ending March 31, 1959.

The accounts before stockholders show the effect of the Rights Issue, which was completed shortly before the Company's year end on March 31st. The issued Ordinary Capital is increased, as is the Share Premium Account, whilst the Cash at Banks reflects the proceeds of the issue.

The consolidated profit before taxation of the Company and its subsidiaries for the year was (to the nearest £1,000) £3,353,000 which was some £17,000 more than for the previous year. At the time of the Rights Issue it was forecast that the consolidated profit before taxation would be not more than 10 % less good than that of the previous year. Estimates for such purposes must be on the conservative side, and in the businesses of the Company's subsidiaries it is not easy to foretell the outcome of current trading. I feel, therefore, that it is a matter of gratification, and not of apology for a cautious estimate, that the consolidated profit has exceeded the forecast.

After taxation the consolidated profit is £1,684,000, some £292,000 more than that of the previous year. The final settlement of the group liability for Excess Profits Levy has enabled a tax provision no longer required of £70,000 to be brought in, compared with £135,000 last year ; but this is the last occasion on which such a credit item can be expected.

For reasons fully explained in the Directors' Report, and connected with the strike in the printing industry, the directors have decided, instead of recommending to the Annual General Meeting a final Ordinary dividend, to pay a second interim Ordinary dividend at the same rate. This will be 6 % less tax which is the rate forecast, subject to unforeseen circumstances, at the time of the Rights Issue. With the interim dividend paid in February, 1959, of 4 % less tax, the total dividend for the year is thus 10 % less tax, the same rate as for the previous year but the second interim dividend is payable on the capital as increased by the Rights Issue.

A large proportion of their earnings has, as usual, been left with subsidiaries, and rather more than enough has been brought, by way of dividend, into the Company's accounts to cover the service of the Company's dividends.

Stockholders will notice that in the Consolidated Balance Sheet, the item "Future United Kingdom Taxation" has this year been divided to show separately the amount of Income Tax that will fall to be paid next January, and the amount of the Taxation Equalisation Account. The balance on this account represents, in terms of tax at current rates, the amount by which the book value of plant exceeds its written down value for taxation purposes. The tax upon this excess has to be found over the remaining life of the plant. In the years when the provision for depreciation in the accounts exceeds taxation capital allowances, the balance on Taxation Equalisation Account will be reduced, and when the contrary obtains it will be increased. In this way the tax on this excess will be debited to Taxation Equalisation Account, and not to Profit and Loss Account. By this system the charge for tax in the accounts each year is more closely related to actual as distinct from taxable profits.

Shipbuilding

The Shipyard and Engine Works at Clydebank continue to be fully employed. s.s. "British Duchess," the first of the 42,000-ton deadweight tankers built for B.P. Tanker Company Ltd., was completed, as was s.s. "Lincoln," a tanker of intermediate size for Federal Steam Navigation Company Ltd. H.M.S. "Tiger" was commissioned and handed over. In her armament and communications she is probably the most modern cruiser afloat.

As has been reported in the Press, Clydebank has for some time been in close consultation with The Cunard Steam-Ship Company Ltd., and has developed with them the basic design for a new express passenger vessel for the transatlantic service.

The modernisation of the West Yard is almost complete. Two berths, served by heavy cranes, have been constructed for the building of large tankers ; and the fabricating shops have been extended. Her Majesty the Queen Mother has graciously consented to name and launch on September 16th s.s. "British Queen," the first large ship from the West Yard, and the first of the 50,000-ton deadweight tankers to be built for B.P. Tanker Company Ltd.

In the East Yard all four building berths are occupied by various types of ship, including ss. "Transvaal Castle" of 33,000 tons gross, a passenger-cargo vessel for The Union-Castle Mail Steamship Company Ltd.

Few new orders for ships are being placed, but in the types of vessel in which Clydebank specialises the outlook is reasonably favourable. Clydebank, with its excellent facilities and trained personnel, is well placed to maintain a leading position in all the developments that are foreseeable in the near future.

Land Boilers and Nuclear Engineering

John Brown Land Boilers Ltd. has had a busy year. The first of the six large boilers for the new C.E.G.B. Belvedere Station on the Thames has been steamed and a number of other large boilers are nearing completion for the Board, as well as two for the South of Scotland Electricity Board, and others in South Africa. The contract has been obtained for the large boiler unit to complete the second half of the Bankside Station in London. A repeat order has been obtained from the Warmbaths Municipality, South Africa. It remains a difficult problem, for the reasons which I gave last year, to obtain enough work to keep Whitecrook Works in full production. It is to be hoped, however, that there will be some easing of the position with the increasing realisation that the modern large boiler, fired by coal or by oil, is inherently cheap and competitive. Production facilities at Whitecrook are excellent, and the organisation is technically well able to play its part in the field of big boilers.

The application of nuclear power continues to be watched with interest but the Company's approach to this subject remains cautious. A contract has been obtained from the U.K. Atomic Energy Authority for the design and manufacture of the refuelling machine for the Advanced Gas-cooled Reactor. This important piece of equipment involves the solution of a number of complex engineering problems.

Machine Tools and Engineers' Tools

In the machine tool industry the recession has continued, but lately there have been signs of a gradual increase in enquiries. Much idle capacity in users' works remains to be filled, however, before the market becomes active again in machine tools. Wickman Ltd. has accordingly not been fully employed in the manufacture of multi-spindle automatics, and, with its smaller order book, it can now quote deliveries to meet the customers' needs. Exports of Wickman automatics have, however, increased, and in particular a sales campaign in U.S.A. has prospered. Wickman's business of factoring imported machine tools has suffered from intense competition, although its specialised sales service, and the wide range of first-class machine tools that it handles, enable it to take every opportunity to sell these machines. Sales of "Wimet" tools, made from tungsten carbide, have held up well.

Webster and Bennett Ltd. continued in full production during the year, and thanks to its heavy backlog of orders, will need to produce to capacity during the current year. Incoming orders have, however, fallen far short of what is required to keep the factory busy thereafter. Webster & Bennett's three basic sizes of vertical boring mills represent excellent value for money and the company receives a satisfactory proportion of orders available.

Firth Brown Tools Ltd. despite very keen competition and the considerable recession in tool buying, has had a satisfactory year. Its success can be attributed to the excellent range and quality of its products and to the untiring efforts of its sales staff at home and abroad. There are now signs of gradual improvement in demand, but the intensely competitive conditions in all markets must reduce profit margins. It is pleasing to report that during the year three senior executives of Firth Brown Tools, who have spent their entire working lives with that company, were appointed to its board.

Other U.K. Engineering Subsidiaries

S. N. Brides & Co. Ltd. has found trading difficult at home and overseas. Demand for portable electric tools continued low, and competition was intense. Recently, however, sales have somewhat improved. The introduction of new tools and attachments and sustained advertising have enabled Brides to retain its place in the forefront of the electric tool business. The rebuilding and modernisation of the large works acquired in the previous year are almost completed, and they will shortly be occupied.

Cravens Ltd. has found that international competition for rolling stock orders for the export market has over the years become more and more intense. British rolling stock manufacturers have little hope of competing effectively overseas unless they have an active home market ; and if the British Transport Commission themselves were to manufacture substantially the whole of their rolling stock requirements, as their workpeople are pressing them to do, that vital home market would be withdrawn from an industry whose contribution to exports has in the last 10 years exceeded £100,000,000. As a result there would be much unemployment among members of Trade Unions which are urging B.T.C. to be self-sufficient ; whereas continued manufacture by the rolling stock industry of a proper proportion of the needs of B.T.C. would assist firms to obtain further export orders, involving further employment.

Cravens has completed its outstanding wagon orders for the home market, and, in view of the poor prospects of more wagon orders, has reorganised some of its shops to increase carriage production and to undertake alternative work. Two important orders were received for carriages from the London Transport Executive, one for 12 prototype motor cars for the Central Line, and the other for 248 light alloy motor and trailer cars for the Metropolitan Line.

Markham & Co. Ltd. has been kept reasonably occupied during the year. Three large drum winders and three large friction winders have been delivered to the National Coal Board, as well as two steel towers for the new colliery at Bevercotes. To the order of Boving & Company two Francis turbines have been delivered to Spain, two sets of Kaplan turbine parts to New Zealand and two further sets of Francis turbine parts to Kariba. Orders unfortunately are not being received at the required rate, the order book is low, and available work ahead is diminishing. This is due partly to the policy of retrenchment on capital expenditure which the National Coal Board have been compelled to adopt in the face of their present difficulties, and partly to intense world-wide competition on water turbines.

Constructors John Brown Ltd. has continued to enhance its reputation for good engineering and workmanship in the chemical engineering field, and has done work for several new clients. Various new engineering and construction contracts have been started which will extend into or beyond 1960. The acrylic fibre factory for Chemstrand in Northern Ireland and the nitro-chalk fertiliser factory for Imperial Chemical Industries at Heysham have, among many other contracts, been completed.

In the Automatic Control Division the volume of work has increased on the assembly of control panels and the installation of control systems. Considerable interest has been shown in C.J.B.'s theoretical design work on automatic and remote control of plants, and C.J.B. is being called upon to advise on various schemes, including the remote control of a pumping station in the Persian Gulf.

In Persia C.J.B. is well established. With six other companies C.J.B. is constructing on Kharg Island a £20 million crude oil terminal connected with the oilfield by a 26/30-inch pipeline, which C.J.B. is laying in a joint venture with Williams Brothers. C.J.B. has been awarded the contract for a sugar beet factory in Persia of 1,000 tons a day capacity ; and also in joint venture with two French firms, the contract for a fertiliser factory at Shiraz combined with a gas pipeline to Shiraz from the oil fields. In Turkey work continues, again in joint venture, on the pumping station for N.A.T.O. pipelines ; but many political difficulties are delaying payments, and are thereby prolonging the work, and making it more costly.

C.J.B.'s research facilities and staff at Leatherhead have been increased. Development work on the pressurised coal gasifier for the Ministry of Power has proceeded intensively. When this work is successfully completed, it may make a major contribution to the economic use of coal. A process of C.J.B.'s for producing heavy water from ammonia, which aroused great interest at last year's Nuclear Exhibition at Geneva, is being developed.

The move into new offices at C.J.B. House, Paddington has enabled all the staff to be for the first time under one roof, with obvious benefit to efficiency.

Overseas Interests

John Brown's Canadian subsidiaries have satisfactorily held their own during a year made difficult by the continued recession. The recent signs of improvement in the economy strengthen confidence in the future of Canada.

In Rhodesia, **F. Issels & Son Ltd.,** in common with other local firms, continues to find competition severe and orders few. **Rhodesian Alloys (Pvt.) Ltd,** has operated satisfactorily. This company represents a new and basic industry to the Federation, and the possibility of a modest expansion of its smelting facilities is under review; the decision turns largely on the price at which it may be possible to buy electricity after the commissioning of the new hydro-electric station at Kariba.

Westland Aircraft Ltd.

The recent acquisition of Saunders-Roe Ltd., by Westland Aircraft Ltd., in which the Company is a substantial shareholder, emphasises Westland's position as the leading British helicopter designer and manufacturer. Its technical, production and financial resources are such as to enable it to undertake with confidence all demands which may arise for helicopters, the future of which seems bright.

Earlier this year Westland opened in London, as a public facility, the United Kingdom's first commercial Heliport. Westland designed this, obtained planning permission for it, and constructed it at its own cost in a remarkably short time; this project fully upholds the imaginative and pioneering tradition of that company. Westland London Heliport is being used extensively, and it is hoped that the experience and data it is providing will be used in due course by the authorities to provide a chain of central heliports in London and the provinces. Following a successful demonstration tour of Northern Europe, the large Westminster gas turbine engined helicopter, which as a crane lifts six tons, recently made the first direct flight from the centre of Brussels to the centre of London. Great interest is being shown abroad in this machine, a second prototype of which has now been constructed. The development costs have been borne entirely by Westland and their engine partners, Napiers Ltd.: it is to be hoped that the British Government will now extend some support to the Westminster, both for its great potential military value and, what is even more important, as a prerequisite to the obtaining of export orders. Westland's principal subsidiaries, Normalair Ltd. and Westland Engineers Ltd., continue to make good progress.

Intense Competition

In reporting on the affairs of the U.K. subsidiaries, I have had to record in almost every case, whether the field is light, medium or heavy engineering, intense competition. When such competition prevails as at present in, particularly, heavy engineering, margins obtainable towards overheads and profit are certainly too small. It is to be hoped that before long there will be a better reward for the skill, experience and knowledge required, and for the commercial risk and technical responsibility involved. This is essential if brains and capital are to continue to be attracted to such work.

Steel

Steel is the main raw material of every one of the Company's subsidiaries, and we, therefore, cannot be indifferent to the political and economic future of that material. Since the de-nationalisation successively of the greater number of the steel companies originally nationalised, each has gone, without exception, from strength to strength. The shortage of steel which only a year or two ago handicapped many industries, has been overcome, and the steel industry, despite the present setback in demand, is still going ahead with its plans to make itself more efficient and its output more competitive. And it is doing this despite the difficulty, inseparable from the threat of re-nationalisation, that there is little incentive for those with savings to invest or risk them in an industry threatened with re-nationalisation, when so many other avenues are open to them. For this reason, in two major schemes Government help has had to be sought and has rightly been given; but this does not constitute an argument for re-nationalisation. Once an industry becomes a pawn in the political game, its efficiency, and the service it can give, are impaired. Labour relations in the steel industry have always been excellent. In the national interest as a whole, and in particular in the interest of those who work in the many industries that use steel, the Labour Party should drop their doctrinaire proposal to re-nationalise steel.

It is only proper that in the foregoing review I should record the main problems facing each subsidiary. To balance these difficulties, however, there are many compensating factors, and, given a reasonable industrial, political and economic climate my colleagues and I look to the future of the Company and its subsidiaries with high confidence.

The credit for a not unsatisfactory year, and for a not unsatisfactory outlook, must go to the skilful guidance and the keen commercial and technical ability of our management, and to the industry and loyalty of our staff and workpeople.

SITUATIONS VACANT

ENGINEER (qualified) for Near East, having considerable experience pipeline, pump station and tank farm construction.—Write fully, stating age, qualifications and experience to BOX No. 2745, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E7093 A

ENGINEERS

Due to expansion, we are requiring two or three additional young men for our Engineering Division. We are a leading company in the paperboard and packaging field and are looking for applicants who have served a recognised apprenticeship in mechanical engineering and have also had good experience in the erection and/or maintenance of multi-cylinder or fourdrinier machines. Minimum qualification H.N.C. Four-figure salaries commensurate with experience and qualifications, will be paid, and there are excellent pension arrangements available with good promotional prospects. Applications, which must state full details of age, education and career to date, should be addressed to.—BOX No. E2518, "The Engineer." A

ENGINEER

required to take charge of maintenance of Head Office premises, Factory and London Depots of large Company. Essentials are good education, mechanical and electrical experience, with a sound knowledge of building works and heating and ventilating systems. A recognised qualification, preferably in Civil Engineering, would be an advantage. The post, which may suit a candidate with experience in a technical branch of the Services, is exacting, carries considerable responsibility for plant and premises, and requires executive ability to control staff and associate with top management executive.

The salary is attractive and there are Profit Sharing and non-contributory Life Assurance and Pension Schemes. Apply in writing, giving full details of age, education, experience and salary expected, to Personnel Manager, E/B, Beecham Foods, Ltd., Beecham House, Great Road, Brentford, Middlesex. E7173 A

ENGINEERING TRAINEE

A unique opportunity exists with one of the leading Food Manufacturing Organisations for an ambitious young man who, having procured the necessary practical experience, now seeks a post which could eventually lead to a position of greater responsibility. Applications are invited from men aged 20/22, who have served a comprehensive engineering apprenticeship, possess O.N.C. (Mech.) and are now studying for H.N.C. Since the training will include visits to the Company's many factories throughout the United Kingdom, applicants must be single and free to travel over the course of the years. The salary will be in accordance with the qualifications required, plus board and lodging allowance whilst travelling. Please write, setting out details of age, apprenticeship, general experience and examination attainments.—BOX No. E7158, "The Engineer." A

ENGINEER SURVEYOR required for inspection of boiler and pressure plant. Must have First Class M.O.T. Certificate with Steam Endorsement or equivalent. Commencing salary £800, rising to £1100. Non-contributory pension and other benefits. Resident Shrewsbury or North Shropshire.—Apply, Eng. Dept., GENERAL ASSURANCE CORP., LTD., 99, Aldwych, W.C.2. E7196 A

ESTIMATING ENGINEER required for Oil Refinery and Chemical Plant Contractors. Applicants must have drawing-office experience and wide knowledge of refinery layout; must also be capable of working to preliminary plot plans and flow sheets. Minimum standard of education: H.N.C. or equivalent.—Write fully, stating age and experience Staff Manager, Foster Wheeler, Ltd., 3, Ixworth Place, London, S.W.3. E7094 A

EXPERIENCED HEATING AND VENTILATING ENGINEER required by Contractors in Westminster. Applicants must be experienced in the preparation of drawings and estimates. Non-contributory pension scheme.—Apply in confidence to Managing Director, J. B. Jackson and Partners, Ltd., 167/8, Millbank, London, S.W.1. 'Phone: Victoria 3933. E2519 A

EXPERIENCED QUALIFIED MECHANICAL ENGINEER wanted to fill the position of WORKS ENGINEER in rapidly expanding processing factory in the Hull Area. The Works Engineer will be responsible for all engineering matters, including maintenance, re-organisation of Plant and erection of New Plant. He will be expected to actively participate in development work connected with new processes.—BOX No. E7069, "The Engineer." A

JUNIOR DRAUGHTSMAN required for work in connection with the design and development of manufacturing plant and special-purpose machines. It would be an advantage to possess O.N.C.—Apply in writing, giving full details, including age, to The Personnel Manager, The Micanite and Insulators Company, Ltd., Empire Works, Blackhorse Lane, Walthamstow, E.17. E7189 A

MAINTENANCE ENGINEER.—Due to internal promotion a vacancy has arisen for a professional Mechanical Engineer to be directly responsible to the Mechanical Engineer of a works employing over 4000 men. Duties include the erection and maintenance of buildings, the installation and maintenance of plant, and the operation of works services.—Please apply, quoting reference CHME/2, to the Personnel Officer (Graduate Recruitment), Pilkington Brothers, Limited, St. Helens, Lancashire. E7185 A

INTERMEDIATE DRAUGHTSMEN required for well established and progressive West of England engineering firm producing high quality pumps. State qualifications and salary required.—BOX No. E7131, "The Engineer." A

MAJOR ORGANISATION REQUIRES:

1. ARCHITECTURAL ASSISTANTS.
2. STRUCTURAL ENGINEERING DESIGN DRAUGHTSMEN.
3. DESIGN and INTERMEDIATE DRAUGHTSMEN experienced in one of the following:—
   (a) Air conditioning.
   (b) Heating and ventilating.
   (c) Plumbing, and
   (d) Sanitation.

Well experienced persons are required immediately for these interesting posts, in London Division. Salaries offered are HIGH. Please reply, with particulars of experience and qualifications, to Managing Director, Ref. X1, BOX No. E7190, "The Engineer." A

MECHANICAL DRAUGHTSMAN—with good all-round experience and capable of making up own specifications, required for senior position in Maintenance Department of large organisation at London Head Office. Some experience of refrigeration an advantage. Non-contributory pension scheme. Write, giving age and particulars of experience.—BOX No. E7191, "The Engineer." A

MECHANICAL ENGINEERS (LONDON)—old-established with well-equipped Machine, Coppersmithing, Plating and Welding Shops producing specialised Machinery, Copper and Stainless Steel Vessels and Conveyor Plant require Experienced ESTIMATING ENGINEER capable of taking charge of Department. Varied and interesting work. Shop training essential. Age 30 to 50. Good salary to right man. Pension Scheme.—Reply with full details of experience as well as technical education to BOX No. E7140, "The Engineer." A

PRODUCTION MANAGEMENT.—If you have recently obtained a good Honours Degree in Physics, Chemistry or Engineering and would like to join the Commonwealth's large glass manufacturing organisation (inventors of Float glass), initially at the Doncaster works, where there is a four million pound extension programme, you are invited to write about yourself to the Personnel Officer Graduate Recruitment, Pilkington Brothers Limited, St. Helens, Lancashire, quoting reference GTD/2. You would be working under arduous conditions, but would be afforded ample opportunity to carry out experiments of your own devising, subordinate to production requirements. Your future would be determined by your energy, initiative and ability to supervise the work of others. E7186 A

QUALIFIED SURVEYOR required, to assist in surveying oil pipeline route in INDIA, preferably with previous experience of this type of work. The engagement will be for approximately one year, commencing about October 1st, and salary (paid in Rupees) will be equivalent at present exchange rate to £1800 to £2000 per annum, depending on qualifications and experience.—Write, stating age, technical qualifications and experience, to BOX TE.116, c/o 191, Gresham House, E.C.2. E7195 A

SALES EXECUTIVE, to take charge of London office of printing machine manufacturers. Applicants should have experience of machinery sales and have the personality and initiative to develop sales of new types of machines. Experience in the printing machine industry and technical qualifications preferred but not essential. Pension and excellent prospects for right man. Reply in confidence, stating age, chronological details of experience and salary required, to Managing Director.—BOX No. E7157, "The Engineer." A

SENIOR DRAUGHTSMAN, experienced, is required by a large Midland Steel Works for essential design work. Knowledge of steel works mechanical engineering desirable but not essential. Applicants should hold H.N.C. or similar qualification. Pension scheme, free life assurance and canteen facilities are provided.—Apply stating age, and giving full details of experience and salary required to the Chief Engineer, BOX No. E7141, "The Engineer." A

SENIOR DRAUGHTSMAN for progressive firm producing Pressure Vessels and similar equipment for Chemical and Petroleum Industries. 5-day week. Canteen and recreational facilities. Excellent conditions. Staff superannuation scheme. Good salary to a fully experienced candidate.—Apply, Towler and Son, Ltd., Riverbank Works, Stratford, E.15. E2517 A

SENIOR ELECTRICAL DESIGNER/DRAUGHTSMEN required by Company in South West London. Must be experienced in industrial lighting and power installations, preferably in chemical or refinery plants. Permanent positions with excellent working conditions and benefits. 5-day week. Commencing salary not less than £925 per annum. In addition, liberal expenses when working initially in Central London.—BOX No. E2522, "The Engineer." A

SENIOR PIPING DESIGNER/DRAUGHTSMEN required by Company in South West London. Must be experienced in chemical or refinery plant layouts. Permanent positions with excellent working conditions and benefits. 5-day week. Commencing salary not less than £925 per annum. In addition, liberal expenses when working initially in Central London.—BOX No. E2521, "The Engineer." A

STRUCTURAL DESIGNER required for work on important and interesting structures of steel lattice construction. Qualifications at least to H.N.C. and good experience in steel construction essential. Age 23 to 27.—Apply, giving all details and salary required, to Personnel Officer (Staff), British Insulated Callender's Construction Company, Limited, 21, Bloomsbury Street, London, W.C.1. E7182 A

STRUCTURAL STEELWORK DESIGNER/DRAUGHTSMAN required for interesting and varied work on building frameworks, industrial steelwork and mechanical handling plants. Age 25–30. Permanent position, excellent prospects, good salary, five-day week, pension scheme.—Apply, stating qualifications and experience, to (Ref. CW) Robt. Cort and Son, Ltd., Reading Bridge, Reading. E7164 A

SURVEYOR (LAND) required, to carry out surveys for industrial development schemes, setting out of structural steelwork and checking civil engineering works. Good starting salary, five-day week, pension scheme, excellent prospects, with opportunity to train as Structural Steelwork Designer. Age 23–28.—Apply, stating details of experience, to Robt. Cort and Son, Ltd., Reading Bridge, Reading. E7163 A

TECHNICAL SALES REPRESENTATIVE, to be based in London, required by well-known Group of Engineering Companies. Knowledge of the requirements of the oil, chemical and heavy engineering industries would be helpful and the position offers considerable scope for a keen, live man. Applications, giving a summary of past career with full details of any previous sales experience.—BOX No. E7160, "The Engineer." A

THE CHESTERFIELD TUBE COMPANY require a DESIGNER DRAUGHTSMAN preferably experienced in medium and heavy engineering handling equipment. Excellent opportunities and scope for the right man. Salary according to qualifications and experience, permanent position, five-day week, contributory pension scheme, canteen facilities, &c.—Apply, stating age, details of past experience and salary required, to Personnel and Welfare Department, Derby Road, Chesterfield. E7171 A

TIME AND MOTION STUDY ENGINEERS required by F. PERKINS LIMITED, Peterborough. Applicants, who should be aged between 25 and 30 years, should have O.N.C. or equivalent qualifications, together with minimum of 3 years' experience in Time Study, Speed and Effort Rating in the light engineering industry.

Preference will be given to applicants having previous experience of work study. Details in writing, including any apprenticeship or other types of specialised training, should be forwarded to the Personnel Manager.

E7193 A

TURBOCHARGER ENGINEERS required for rapidly expanding department of engine accessory manufacturers. Preferably a Graduate, but experience in diesel development essential, together with the ability to discuss design and application problems and at all levels.—Write, stating age, experience and present position, to the Manager, Turbocharger Department, Holset Engineering Co., Ltd., Turnbridge, Huddersfield. E2500 A

U.S.A.: SETTERS, FITTERS, TOOL DIE MAKERS/SETTERS, &c., wanted. High salaries, fares advanced. 15s. to 18s. an hour upward, plus bonus.—Write details of experience to Maida Vale Bureau, 444, Edgware Road, W.2. (Tel.: Willesden 3857.) E2515 A

WORKS MANAGER

required by

JAMES RESIDE LIMITED, GENERAL ENGINEERS, BRIGHOUSE

Applicants should have production and planning experience of Welded Fabrications and all ancillary machining and fitting operations.

Alert and enthusiastic men should write, giving details and full particulars of experience, qualifications and salary required, to MANAGING DIRECTOR. Only men of proved ability, please.

E2508 A

WORK STUDY

A major industrial organisation requires a trained WORK STUDY ENGINEER with 3 to 5 years' experience in medium industry. The successful candidate must be able to work without detailed supervision and should also have some knowledge of mechanical handling. This is an interesting position and prospects are quite bright.

Please write stating full details of age, experience and qualifications to BOX No. E7204, "The Engineer." A

NORTHROP

DESIGN DRAUGHTSMAN

experienced on automotive type transmissions and torque converter application. Knowledge of heavy duty axle construction an advantage. Must have at least five years' experience in this class of work. Age group 25–30. H.N.C. standard.

Apply in writing to:

The Labour Officer, Constructional Equipment Division, BRITISH NORTHROP LIMITED, Blackburn.

E7187 A

MECHANICAL, INSTRUMENT and ELECTRICAL ENGINEERS

COURTAULDS, LIMITED, requires Graduate Mechanical, Instrument and Electrical Engineers, aged 25 to 40, for important work in the design, construction and maintenance of large synthetic fibre and chemical plants. Candidates should have a good Honours Degree in Mechanical or Electrical Engineering, and, for the junior appointments, preference will be given to those who have already completed a suitable apprenticeship and had two or more years' experience in the design or maintenance of industrial plant.

The vacancies are additional permanent appointments, with very good opportunities for obtaining a wide experience in the process engineering and contracting fields and prospects of promotion for men with an original approach to problems are excellent. The work is exceptionally varied, covering the complete range of engineering activities from heavy industrial equipment, including boiler and power plant, to fine mechanisms and highly specialised machinery of Courtaulds' own design; also the distribution and application of electrical energy.

Successful candidates will be given the necessary background knowledge of the various processes concerned to enable them to further the development of modern manufacturing techniques and automatic control in the industry.

Financial assistance is normally awarded to married men when moving house. The appointments are pensionable and the occupants will be eligible for co-partnership benefits.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds, Limited, 16, St. Martin's-le-Grand, London, E.C.1, quoting reference number B.55.

E7199 A

NORRIS CONSULTANTS LTD.,

in view of a two-year expansion programme, require for their London and Bristol Offices and elsewhere in the U.K., Senior and Junior Engineers, Designers and Draughtsmen in the fo lowing fields.

CIVIL ENGINEERING DIVISION

Reinforced Concrete, Heating, Ventilating, Air Conditioning, Refrigeration, Pipework and General Services, Structural Steelwork.

PRODUCTION & MECHANICAL DIVISION

Special purpose machines, Transfer Systems, Jigs and Tools, General mechanical, Mechanical Handling, Electrical (Heavy and Light current).

Salary scales up to high level in accordance with age, experience, technical and professional qualifications. Pension and Insurance schemes. Write or telephone Head Office, Beacon House, Queens Road, Clifton, Bristol. Tel.: Bristol 3-6817, or those requiring appointments in London Area, write or telephone: 76, Victoria Street, S.W.1. Tel.: VIC 4675.

E7020 A

SITUATIONS VACANT

DESIGNER DRAUGHTSMEN

for work on
Machine Tool Design and Development
are required by
THE NEW DEVELOPMENT
and
PROCESS DEPARTMENT,
ENGLISH ELECTRIC, RUGBY

Applicants should be of H.N.C. standard and have served a recognised apprenticeship, leading to experience of machine tool or jig and tool drawing-office work.—Please write full details to Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E 1199T.

E7098 A

SITUATIONS VACANT

SALES MANAGER

This rapidly expanding Company requires the services of an able and energetic SALES MANAGER (Home Sales only). Previous experience in the Ball and Roller Bearing Industry would be a distinct advantage, but it is even more important that candidates are already successfully holding a position as Sales Manager. The successful candidate must have a proved Sales record, must be a good organiser, and, in addition, must be prepared to spend lengthy periods away from home.—Please apply in writing with full particulars to The Secretary, F'AG Bearing Co., Ltd., Macrome Road, Green Lane, Tettenhall, Wolverhampton.

E7172 A

MANAGER—PUBLICITY DEPARTMENT

Owing to the promotion of the present office holder, Metropolitan-Vickers Electrical Co., Ltd., an AEI Company, invites applications for the position of Manager of its Publicity Department at Trafford Park, Manchester.

The Manager of the Publicity Department is responsible to the Commercial Director of Metropolitan-Vickers for the overall publicity for the four Associated Electrical Industries Product Divisions managed by Metropolitan-Vickers, as well as for the Company's departments. The divisions cover turbine-generators, switchgear, traction equipment, and transformers. He has a staff of 85. He is required to work in close liaison with the Manager of the A.E.I. Central Information Department in London.

This position demands a high level of both creative and administrative ability. Applicants should be in their early forties, have an engineering background and a wide experience of technical publicity.

Applications, in the form of a full statement of personal details (including present salary) and experience, should be addressed to :—

The Manager, Personnel Department,
Metropolitan-Vickers Electrical Company, Limited,
Trafford Park, Manchester, 17

Applications will be treated as strictly confidential. Please mark envelope Q 13.

E7183 A

SENIOR ESTIMATING ENGINEER

KELLOGG
INTERNATIONAL CORPORATION

OFFERS FIRST CLASS SALARY TO FIRST CLASS MAN . . . . .

. . . . . and the opportunity to work and to grow in a firm renowned throughout the oil refining and petrochemical field. Our staff enjoys the benefit of Kellogg's 50 years' accumulation of experience and " know-how " in this highly technical industry.

The man we seek should be capable of estimating the various categories of oil and chemical equipment and materials, and to produce competitive tenders for plants both here and abroad of considerable magnitude. An engineering degree will be an advantage. A background of quantity surveying will be useful if combined with broad experience in mechanical or chemical equipment. The position, which is permanent, offers real scope for a man of ability and initiative.

Fringe benefits include Luncheon Vouchers, contributory pension scheme, sickness and life assurance and a Social Club.

Apply by letter only to Personnel Manager,

KELLOGG INTERNATIONAL CORPORATION,
7-10, CHANDOS STREET, CAVENDISH SQUARE, LONDON, W.1.
(Please quote reference 145/9.)

E7152 A

SITUATIONS VACANT

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

APPLICATIONS BRANCH

NUCLEAR ASSESSMENTS SECTION **Ref. ENR/329**

Applications are invited for the following vacancies at new laboratories located in the South of England.

(a) **MECHANICAL ENGINEERS,** for work directed towards gaining experimental information to enable accurate estimates to be made of the performance of **advanced nuclear reactors and ancillary equipment.** Successful candidates will be engaged initially on the design of **heat transfer apparatus** and subsequently on experimental work.

Applicants should have an Engineering Degree and a good knowledge of heat transfer, coupled with practical experience in this field. Knowledge of nuclear engineering is desirable, but not essential.

(b) Applications are also invited from recent graduates and from engineers with less experience in this work, to assist in the above projects.

(c) **MECHANICAL OR ELECTRICAL ENGINEERS,** with a good knowledge of nuclear power reactors, to join a small group engaged upon the **assessment of advanced reactors.** Duties will include the formulation of supporting experimental work and participation in this work as required.

Candidates should have an Engineering Degree and several years' industrial experience.

Salaries will be on scales within a range rising to £1300, according to duties and responsibilities. Opportunities for promotion in an expanding organisation are good.

Further information, if required, may be obtained by ringing CHAncery 2866, Ext. 134.

GENERATION SECTION

at the RESEARCH LABORATORIES, LEATHERHEAD, SURREY. **Ref. ENR/330**

ENGINEER OR PHYSICIST required to take charge of a small team working on basic research into the mechanism of MECHANICAL SEALS for use in large boiler feed-pumps and high-pressure gas circulators.

Applicants should possess an Honours Degree or Membership of the Institute of Physics, and have a sound knowledge of **fluid dynamics.** Previous research experience is essential, although this need not necessarily have been in this particular field.

Salary within the range £1195–£1775 p.a., according to duties and responsibilities.

DESIGN AND CONSTRUCTION DEPARTMENT

POWER PLANT DESIGN BRANCH

at HEADQUARTERS, LONDON, S.E.1. **Ref. ENR/331**

Applications are invited for the following appointments. The Power Plant Design Branch **is responsible for the design of boiler, turbo-generator and ancillary plant in conventional power stations,** and for the design of plant other than reactors and their ancillaries in nuclear power stations. It is staffed mainly with engineers specialising in individual items of power plant, or in particular aspects of those items, and works in close collaboration with those responsible for the operation of the Board's power stations.

(a) **ASSISTANT ENGINEER, BOILER PLANT**

Duties will involve primarily the investigation of the chemical engineering aspects of the design of boiler plant for both conventional and nuclear power stations, with some relation also to coal handling and preparation plant, draught plant, gas cleaning plant, and ash and dust disposal plant, the emphasis being on the fuel and ash, combustion and gas side, not on the water side.

Whilst the post essentially requires training in chemical engineering and experience in the design of power plant or chemical plant, the successful candidate will work as one of a team of engineers specialising in various aspects of the design of the items of plant enumerated, so that opportunity will be afforded him to widen his existing knowledge. Consideration will, therefore, be given to candidates whose training has been primarily in the chemical aspects rather than in engineering, provided that they have had some experience in power stations or engineering works, and have some basic knowledge of heat exchange and stress calculations.

Candidates should have a Degree in Engineering or Science and/or Membership of an appropriate Professional Institution.

Salary within the range £1245–£1835 p.a., according to duties and responsibilities.

(b) **ASSISTANT ENGINEER, TURBINES**

Duties will involve investigation into technical and economic problems associated with the application of steam and gas turbines and their auxiliaries in both conventional and nuclear power stations, leading to the development of specifications and to the critical assessment of the technical features and performance of specific designs.

Candidates should have a Degree in Mechanical Engineering and/or Corporate Membership of the Institution of Mechanical Engineers, and previous experience in the design of turbines for central power station application.

Salary within the range £1475–£1940 p.a., according to duties and responsibilities.

(c) **ASSISTANT ENGINEER, GENERAL AND CO-ORDINATION**

Duties will be to assist in the investigation of technical and economic problems which are of a general nature or which arise in the integration of the design of the separate plant items into a co-ordinated whole.

Candidates should have a Degree in Mechanical Engineering, together with a knowledge of Applied Thermodynamics. Previous experience of power station plant would be advantageous, but is not considered to be so important as ability to make critical appraisals.

Salary within scale £1245–£1605 p.a.

(d) **METALLURGIST**

Duties will be to provide metallurgical advice to the various plant specialists in the Branch and to maintain liaison on metallurgical matters with the Board's Research and Development Department.

Previous experience in the high-temperature field is considered to be particularly desirable, but the work will embrace all aspects of the selection of materials for power plant and cover both ferrous and non-ferrous metallurgy.

Salary within the scale £1475–£1835 p.a.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1., by 7th September. Envelopes should be marked " Confidential " quoting relevant reference number.

E7178 A

Classified Advts. continued on page 140

SITUATIONS VACANT

BRITISH TITAN PRODUCTS COMPANY LIMITED

have vacancies for

MECHANICAL ENGINEERS

at their Grimsby and Billingham Factories.

The Company is primarily concerned with the manufacture of Titanium Dioxide and is characterised by a tenfold expansion in post-war years. This continuing expansion offers plenty of scope for Engineers in the fields of Plant, Maintenance, Construction and Design. The current vacancies are for Maintenance and Construction work with opportunities later in the Design field.

Preference will be given to candidates with a University Degree in Mechanical Engineering, but those with an equivalent professional qualification will also be considered. Post-graduate apprenticeship is essential and the upper age limit for the appointments is 30.

Salaries and prospects are very attractive for men with the right qualifications. Annual bonus scheme and non-contributory endowment assurance and assistance for married men with house purchase and removal expenses.

Applications, in strictest confidence, to be addressed to the

Personnel Manager,
British Titan Products Company, Limited,
Billingham, Co. Durham, quoting reference S.4.

E160 A

CIVIL ENGINEERING CONTRACTORS

of international repute require

PROJECT MANAGER

for major contract in West Africa

Applicants should be qualified civil engineers with considerable contracting experience in U.K. and overseas. They should preferably be between the ages of 35 and 50 and should have held positions of responsibility on river works and bridge foundation construction. In addition to being a sound engineer, the selected candidate must be a capable organiser and administrator.

The salary offered is £4000 and good free furnished family accommodation is available. Tours are of 12/18 months duration, after which generous paid home leave is given. The Company pays for transport.

Please write fully and in confidence.—BOX No. E7125, " The Engineer."

A

ENGINEERS
and
TECHNICIANS

are required for work on a large proton synchrotron being built at Harwell for the NATIONAL INSTITUTE for RESEARCH in NUCLEAR SCIENCE.

The **ENGINEERS** are required for

- commissioning (and subsequently maintenance and modifications, extensions &c., of electrical and electronic instrumentation (Ref. 5032/25), and for following work through from inception to completion in the fields of
- mechanical design (Ref. 5035/25),
- design and application work on general electrical problems connected with the synchrotron and on stabilised D.C. supplies involving large motor generator and rectifier sets (Ref. 5036/25), and
- design of control and safety sequences equipment (Ref. 5037/25).

The **TECHNICIANS** are required for

- commissioning, fault investigation, repair and testing of electronic equipment (Ref. 5033/25),
- supervising the inspection, installation and maintenance of mechanical plant (Ref. 5034/25), and
- organising inspection and proof testing of equipment and subsequently assisting in running a technical office and planned maintenance scheme (Ref. 5038/25).

The Engineers should be corporate members of senior engineering institutions : salary, £1345–£1800.

Technicians should have served a recognised engineering apprenticeship or have had equivalent training. They should have had appropriate experience and (for 5033 and 5034) should preferably have O.N.C. Salary : (5033 and 5034) £905 (at age 30)–£1085 and (5038) £725 (at age 26)–£905.

Housing assistance and superannuation.

Please send a POST CARD for details.

QUOTING APPROPRIATE REFERENCE NUMBER,
to the Group Recruitment Officer,
U.K.A.E.A., A.E.R.E., Harwell, Berks.

E7161 A

SITUATIONS VACANT

EXECUTIVE MECHANICAL ENGINEER

required for a well-established general repair shop in Trinidad—M.I.Mech.E. or A.M.I. Mech.E. qualifications, with general practical experience in Turbines, Diesels and Reciprocating Engines, and all types auxiliaries, with extensive Machine Shop and Foundry experience. Age 40/45 years. Commencing salary £2000 per annum. First-class steamer fare will be provided for self and wife and including up to children under 18 years of age. House with hard furniture will be provided at a rental of 10 per cent of salary. Three-year contract in first instance with two weeks' local leave annually after 12 months' service—home leave of three months after completion of contract.

Write, BOX " W.K.," c/o J. W. Vickers and Co., Ltd., 7/8, Great Winchester Street, London, E.C.2.

E7177 A

RESEARCH ENGINEER

MECHANICAL ENGINEERS are required by COURTAULDS, LIMITED, for its Research and Development Organisation in Coventry to work on a wide variety of process development and pilot plant operations. Applicants should possess a First or Second Class Honours Degree in Engineering, be not more than 28 years of age, and have had not less than 2 years' industrial experience.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds, Ltd., 16, St. Martin's-le-Grand, London, E.C.1, quoting reference number D.93. E7198 A

SITUATIONS WANTED

MECHANICAL ENGINEER (30) seeks responsible position, small firm, or will undertake Mechanical Project under contract. University education, good research and design experience and SPECIALIST KNOWLEDGE HIGH-SPEED PAPER HANDLING. North London/Herts.—BOX No. E2505, " The Engineer." B

TECHNOLOGIST, 35, lifetime experience in iron and steel (engineering, instrumentation, research and fuel) seeks senior position. Minimum salary £1600.—BOX No. E2514, " The Engineer." B

BUSINESSES and PREMISES

INDUSTRIAL ACCOMMODATION Light Engineering Storage 5000 super with Office Block and 8000 super. All services including Private road, Car Park, near Great South West Road. Reasonable rental.—Macks Structures (London), Ltd. Feltham 5761. E2504 L

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 G

ADVERTISER, PRIVATE INVESTOR desires to purchase whole or part interest in concern under progressive management making annual net profit of £15/50,000.—BOX No. E163, " The Engineer." G

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

PATENTS

THE PROPRIETOR of British Patent Nos. 711298, 711299 and 709958, entitled " Improved Plug Closures For Handholes and the Like of Pressure Vessels," " A Gate Valve With an Improved Bonnet and Sealing Means Therefor," and " Improved Plug Closures For Hand and Like Holes in Pressure Vessels," respectively, offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Boulevard, Chicago, 4, Illinois, U.S.A. E7203 B

FOR HIRE

BELLMANS MASTS FOR HIRE, to lift from 1 to 20 tons, 30ft. to 150ft. Blocks and tackle. Hand-operated winches. From £1 per day.—BELLMAN'S (Phone : SLOane 5259), Hobart House, Grosvenor Place, S.W.1. E103 K

MACHINERY Etc. WANTED

ONE 500 H.P. and two 600 H.P. D.C. adjustable speed Main Roll Mill Motors, 475/900 r.p.m., complete with control gear and instrumentation.—BOX No. E7081, " The Engineer." F

URGENTLY REQUIRED. Several 3½/4 cu. yard GRABS to work with Lima 1201 Excavator, suitable for shale. Full details.—BOX No. E107, " The Engineer." F

ONE 450kVA. BELLISS AND MORCOM STEAM SET, 400/3/50, 4-wire supply, 150 to 160 lb. input, 5 to 10 lb. output.
ONE 150kVA. SET as above.
BOX No. E2520, " The Engineer."

FOR SALE

FRED WATKINS (ENGINEERING) LTD.

Fielding 500-ton Vertical Downstroke Hydraulic Press, 42in. by 36in. platens, with pumps and motors.
Fielding 200-ton, ditto, 3ft. stroke, with pumps and motors (5 available).
Fielding 100-ton ditto, 4ft. to 5ft. stroke, with pumps and motors.
Two 73ft. 4in. by 5ft. Kilns or Dryers, with Crofts Reduction Gear and 27 h.p. motor.
Two 26ft. by 4ft. Rotary Cooler or Dryers, with reduction gear and motor.
Available at low prices ex present sites to save cost of bringing into stock.

FRED WATKINS (ENGINEERING), LTD., COLEFORD, GLOS. E151 G

FOR SALE
ASQUITH 5ft. model L.D.I.
RADIAL DRILLING AND TAPPING MACHINE,
No. 4 M.T., with loose box table.
F. J. EDWARDS LTD.,
359–361, EUSTON ROAD,
LONDON, N.W.1.
EUSton 4681 and 3771.

E7148 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft., and 30ft. wide huts ; also " Romney " Huts, 35ft. wide, and " Blister " Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel. : Bexleyheath 305). E113 G

75FT. LONG BY 11FT. 3IN. DIA. Horizontal, Mild Steel, Riveted PRESSURE VESSEL, designed for a working pressure of 240 p.s.i., as a steam accumulator.—BOX No. E7156, " The Engineer." G

FOR DISPOSAL—Approximately mid-end 1960. 12ft. roughing mill train comprising heavy plate rolling stand with pinion housings and spindles. Rolls nominally 42in. by 12ft. long on barrel. This equipment does not include electrics. For further particulars apply Appleby-Frodingham Steel Company, reference P/EB, Scunthorpe, Lincs. E162 G

FOR SALE " Metrovick " Infra Red Paint Stoving equipment, comprising 2 frameworks each fitted with 3-4ft. long, 5·3kW units, 415 volts, 3-phase, 4-wire Control Box with 2 energy regulators and spare starter interlocked for use with conveyor. In good condition. Situated London W.3 area.—Reply BOX No. E7200, " The Engineer." G

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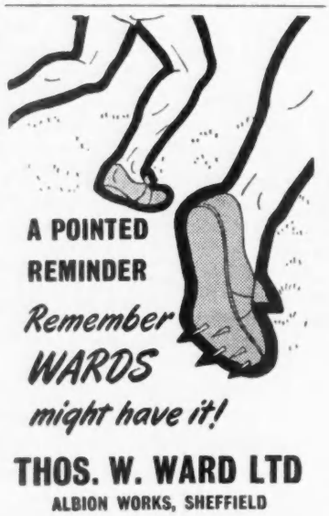

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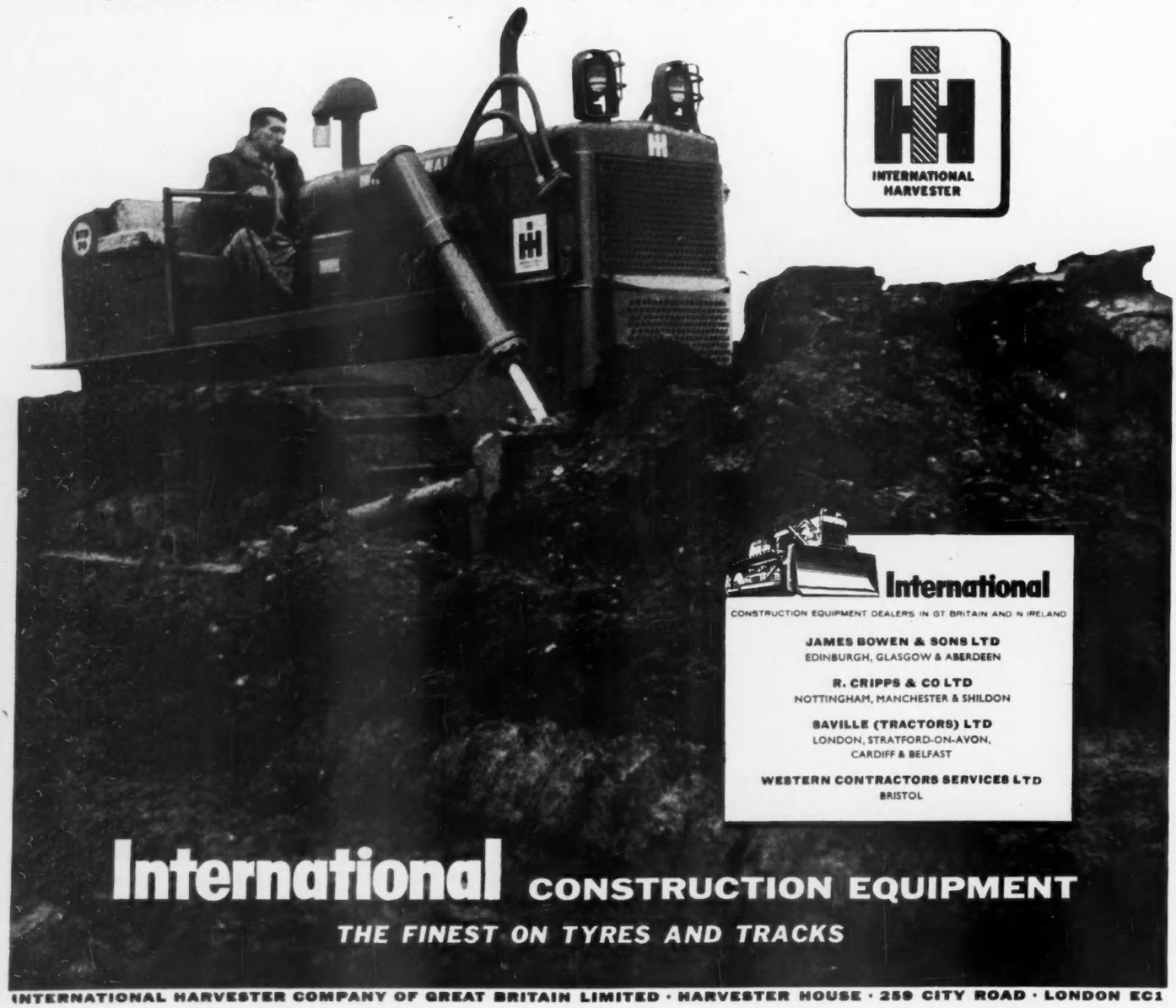

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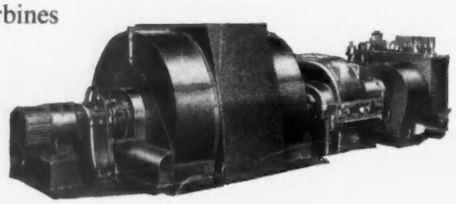

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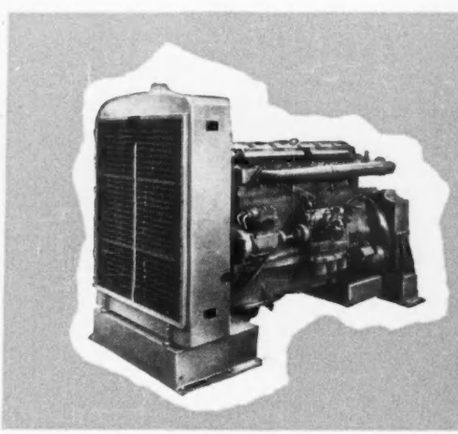

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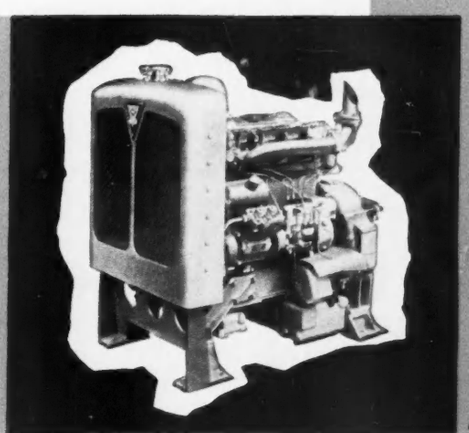

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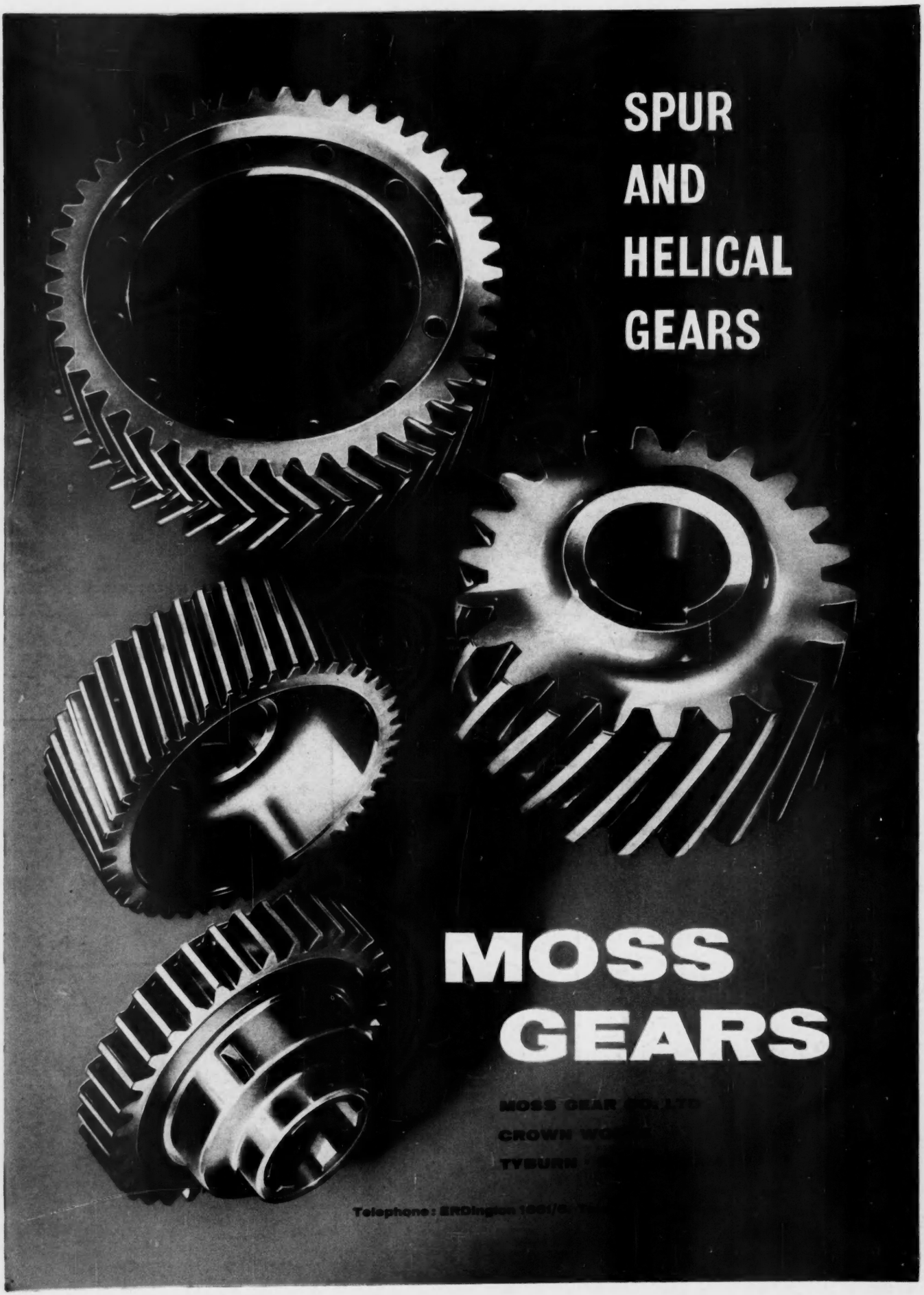
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